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A CALENDAR SYSTEM OF RECORD KEEPING FOR SPORTSMEN

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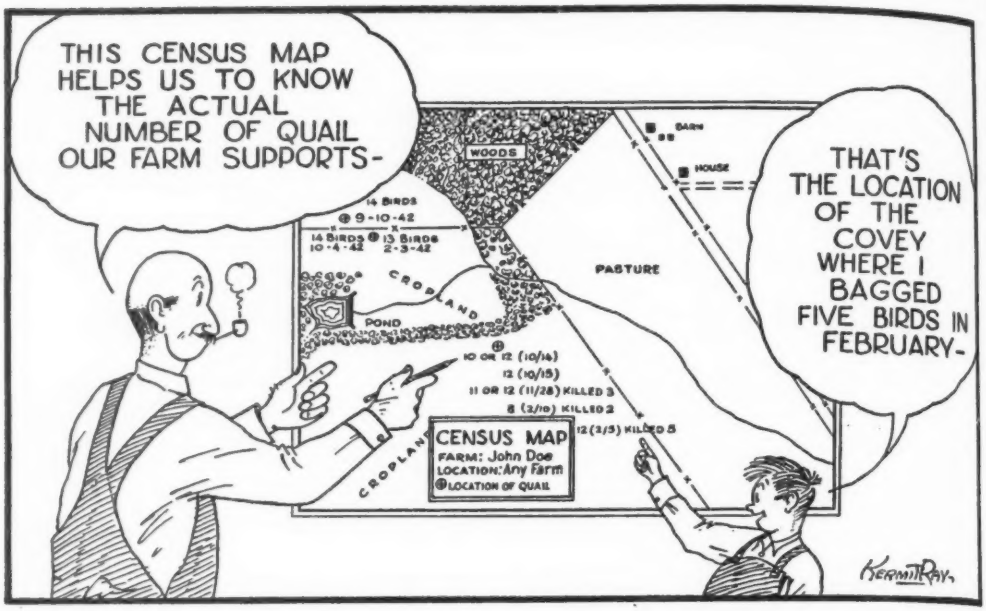
Several branches of wildlife conservation still lack substantial developments for the want of a suitable technique to determine carrying capacities of lands and waters and to record the game, fish, and fur-bearers taken by the consumers of these products. A better system of inventory will answer many of the more perplexing details facing every state in the administrative and technical problems.

All states have doubtless tried by one method or another to get an accurate report of the game killed annually by each hunter. Thousands of dollars have been spent on state-wide surveys. In fact, the moneys and efforts applied to wildlife inventories have increased remarkably of recent years. Questionnaires have been sent to hunters, farmers, teachers, and county agents in a number of states. Some, like Alabama and Virginia, have checked the answers by inquiries, by the use of hunting dogs, and by observations. Others, like Tennessee, have distributed 10,000 or more cards to hunters for voluntary reports. Pennsylvania and Michigan make reporting mandatory and there is agitation in other states to establish similar systems.

Considerable information has been obtained by these methods but all are far short of the data which are needed for wildlife restoration and management. Most of the methods have a basic fault. Few are founded on actual records kept by the reporting hunter, fisherman, or farmer at the time of harvest. Questionnaires have been sent to persons who were not prepared to furnish the information requested. The answers, naturally, are opinions or estimates made hurriedly from memory. Such a system is inaccurate and misleading.

Most game management projects today are really experiments, and actual records are essential to further improvement. Thousands of dollars have been wasted in surveys and on hopeful developments that never were proved good or bad. Several programs involving farm-game, fish, and fur-bearers, are being continued amid doubt and argument as to their true success or failure. Without records no one can diagnose the actual effects of even the simplest environmental manipulations. With measurements considerable improvement would be possible on several techniques although abandonment should be expected of others. Abandonment of uncertain projects due to reductions in funds for wildlife management during the war is immediate, and the virtue of correcting misconceived programs,


THIS CENSUS MAP HELPS US TO KNOW THE ACTUAL NUMBER OF QUAIL OUR FARM SUPPORTS-
THAT'S THE LOCATION OF THE COVEY WHERE I BAGGED FIVE BIRDS IN FEBRUARY-
WOODS
BARN
HOUSE
PASTURE
CROPLAND
POND
14 BIRDS @ 9-10-42
14 BIRDS @ 13 BIRDS 10-4-42 2-3-42
10 OR 12 (10/14)
12 (10/15)
11 OR 12 (11/28) KILLED 3
8 (2/10) KILLED 2
12 (2/5) KILLED 5
CENSUS MAP
FARM: John Doe
LOCATION: Any Farm
@ LOCATION OF QUAIL
KERMIT RAY

Any Farmer Can Keep a Census—On a Map

Record of Fish and Game Taken

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Quail																																
Rabbits																																
Squirrels																																
Bream																																
Bass																																

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Few people actually know how many quail their farm supports—But anyone can make a map of his farm and then record the place and date where each covey is seen. A season's record (September through March) will reveal (1) the number of birds, (2) the kind of cover and food that supports a covey, and (3) where no birds exist.

Census maps will answer these questions: Is the number of birds increasing or decreasing? Do your "wildlife-lands" support coveys every year? What percent of the birds can be harvested safely?

Try a census-record! Make a rough map of the fields, woods, and pasture on your farm! A blank page is included at the back of the calendar for this purpose. Put a small "x" on the map to represent the location every time you see a covey. Show the number of birds and the date each time. Review the whole pattern once in a while. It's easy to learn.

Fig. 1. Sample page (calendar portion omitted) from record calendar for sportsmen.

though less apparent, is none the less important. The fact remains, however, that few states or agencies are prepared to choose between projects that may or may not be serving the best interests of conservation. Moreover, most decisions will be based on opinions until crude estimates are replaced with definite

data. The vision of post-war projects should be a real incentive to study present projects carefully during the war period.

J. P. Miller and B. B. Powell (U. S. Dept. Agric., Circ. 636, 1942) summarized the situation as follows: "There is almost no statistical information pertaining to game and wild-fur production and utilization. . . . No technique has been devised that will provide an adequate inventory of the living game and fur animals of a state. The only available figures . . . are rather crude estimates.

"The need for providing facilities in State and Federal Government for collecting, analyzing, and supplying reliable and comparable wildlife statistics is apparent."

Actual records can be obtained by the use of a wildlife calendar which provides spaces for recording game and fish taken every day of the year. Any hunter, fisher, trapper, or farmer will find the system easy to follow, interesting to keep, and helpful in determining the carrying capacity of the lands on which he must depend for sport, food, or recreation. Information from actual records is generally dependable. Many biologists and game specialists believe erroneously, that only a trained technician can take stock of wildlife in a habitat. This thought is prevalent largely because a simple method has never been designed and perfected.

A wildlife conservation calendar, developed by the author and now available, is $8\frac{1}{2}\times15$ inches with a separate sheet for each month. The first issue provides for 1943 plus September to December, 1942, to start with the open fall seasons. A portion of the calendar sheet for October 1942 is reproduced herewith (Fig. 1) to show the style of presentation and to indicate the breadth of approach. A cardboard front extending below the monthly sheets can be had with the name of the organization using it and an individual message of introduction. The name remains visible when the front sheet is behind. Sheets are turned at the end of the month—none is torn off—to retain the records as they develop. The present calendar has 16 sheets but subsequent issues will have only 12 months.

The calendar system accomplishes the following significant things:

1. A continuous reminder of the subject is kept before the user. Projects without timely suggestions and interesting reminders for the laymen usually obtain discouraging results.

2. A handy means of recording facts about wildlife is provided in a simple chart on each sheet.

3. Interest and serious thought are aroused by editorial cartoons.

4. Timely conservation suggestions encourage active participation in the development of a better outdoors every month.

5. Homely principles of wildlife conservation are appropriately presented in proper sequence.

6. A system of censusing quail is shown.

State game departments will find the calendar system most effective (1) to determine the relative kill on opening days, holidays, and other days of the season; (2) to measure the total amount of one or several species taken; (3) to learn the carrying capacities of a single farm in terms of quail, squirrels, rabbits, pheasants, etc.; and (4) to plot upward

or downward curves in the fortunes of any animal on any given area—farm, pond, or field. From them the influencing factors can be studied specifically. Universities and cooperative wildlife research units will also find this system useful.

Calendars are appropriate for projects of several types:

1. Active game clubs can have their members keep a record of their hunting and fishing and then have a committee analyze the results in a standard manner recommended by the state technician in charge of surveys. By this method a state avoids the cost and employment of burdensome (and virtually impossible) statistical analyses. Participating sportsmen learn interesting facts that lead to deeper understanding of technical and administrative problems in game conservation. The entire state, a percentage of the state, a single club in every county, or any suitable number of clubs can participate.

Calendars are given to members and a list is kept of those receiving them. A check-up can be made at any time, following individual seasons, or at the end of the calendar year. Data should include the total number of calendars distributed and a breakdown of those lost, unrecorded, inaccurate, and kept satisfactorily. The actual data desired will vary according to the wishes of the state and the individuals, but they can include the number of days hunted or fished, the numbers of 8 or 10 species taken, the dates of greatest activity, and expressions of interest from the keepers of the records. One man can easily and rapidly distribute several thousand calendars, direct a uniform study of significant facts, collect the data from groups, and summarize the results. The technique is simple because a basic system is employed.

2. A farm-game program or a restocking program will be carried out more intelligently if each land occupant is given a calendar including directions and helpful hints. It is poor economy to expend $10 to $25 or more per farm to initiate a program without following it up with essential information presented at timely intervals. As pointed out earlier, it is also time that the sponsors of projects seek the faults and improve the methods of their original plans before too much time elapses.

3. In view of the recent emphasis in attempting to interest agricultural workers in wildlife conservation along with broader soil conservation programs, it is evident that proposals should be presented strikingly to certain leaders. If ample consideration is to be expected, wildlife conservationists will have to prepare the way. Every game warden should learn the few practical measures of soil and wildlife conservation as taught by the wildlife calendar. The five supervisors of each soil conservation district, every county agent, and every SCS farm planner, should have reminders before them. This is a direct approach to securing cooperation of the individuals who govern action programs in the field. Their own hunting data can be added to the records from clubs and individual hunters.

Where seed, or fencing, or other material are given to district cooperators for environmental improvements, a calendar is the logical companion to accompany the new recruit into a relatively new phase of farm management.

4. A record should be kept by the

owner of every pond to determine the fishing which that pond affords. No greater controversy exists today than the relative merits of fish-farming techniques, what species to use, how many to stock, and how heavy to fish these waters. A calendar record given with every shipment of fish will help answer the question for the fish specialists.

5. The calendar is well suited to 4-H Club work. One or more separate projects, such as fish farming, wildlife-land development, game survey, game harvest, or general conservation, can be guided and furthered by this instructional system.

6. The public relations angle is recognized as a substantial justification for many activities in the field of wildlife conservation. Any number of publications, some restocking, and most publicity have been issued for this sole purpose. The calendar deserves mention as a public relations agent in addition to its more obvious educational appeal.

A game census of any kind of farm game can be kept by the owner better than by an outsider. In fact, game management implies a reasonable knowledge of how many birds exist on a given property before the season, the natural expectancy of harvest, the hunters that can be accommodated, and a knowledge of the shelter and foods which are essential. Game management can never be practiced successfully unless techniques of inventory are simplified for the laymen. The calendar develops this theme progressively.

A WINTER WILDLIFE CENSUS IN NORTHEASTERN WISCONSIN

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In March, 1934, the writer directed a wildlife survey by four interested and capable C.C.C. enrollees in the Nicolet National Forest, Forest County, Wisconsin. The methods used, data on animal populations, and densities are published here by permission of the U. S. Forest Service, Region 9.

AREA SURVEYED AND WEATHER

The country is of rolling topography, characteristic of a glaciated region—a knob-basin topography, including extensive muskegs. Previously it supported mature stands of hardwoods and conifers, and in 1934 showed evidence of recent burns. There was much coniferous reproduction as an understory of aspens, and many isolated overmature forests of hemlock and birch. Red pine, white pine, and white spruce reproduction was heavy in many places. The swamps contained cedar, black spruce, and tamarack, interspersed with many thickets of alder and willow. This brush was difficult to travel through, and when the snowshoes struck the stems they made sufficient noise to alarm animals ahead; few animals therefore were seen in such cover. Bea-

ver dams often flooded areas along the stream bottoms, making travel difficult or impossible, and necessitating long detours. The cover types were varied in character and age classes because of the topography and interrupted drainage; in size they ranged from islands of an

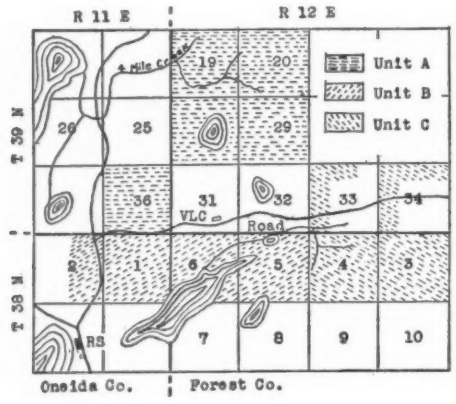

Fig. 1. Area covered by the Virgin Lake Camp (VLC) Game Survey, Nicolet National Forest, Argonne Unit, Forest and Oneida counties, Wisconsin (after U. S. Forest Service Map). RS, Ranger Station.

acre in the muskegs to solid stands of about 500 acres.

Weather records were taken during the survey. The 7 A.M. temperature minima varied from −10° to +32°F., and the noon temperature from 10° to 35°F. Zero temperatures might possibly cause the animals to be less active, and snowfall or wind could obliterate tracks, when the counts next day would indicate few animals, but no such relationship was found. Thus, the density figures for snowshoe hares were 1.1 and 0.3 on two days of 0°F. at 7 A.M., and on a morning of 26°F. were 1.8 and 0.6; the density of 1.8 was the lowest indication of abundance on any section surveyed. Other comparisons on days of 2° and 5°F. versus 32°F. showed no relationship between the temperature and degree of activity. The same was true for deer as the four coldest mornings afforded density ratings of 21, 21, 9.3, and 1.2, and the four warmest mornings of 11, 3.6, 1.1, and 2, respectively. For ruffed grouse the three coldest temperatures (0°, 2°, and 5°F.) showed 1.2, 15, and 7 acres per bird. Hence animal activity apparently was not influenced by cold spells within the temperature ranges experienced (Table 2).

The depth of the snow varied from two feet in the open to six feet in the cedar swamps. Not enough snow fell during the survey to cover tracks, but there were several windy days which may have had a bearing on the number of tracks seen in the open places. The only animals likely in such places were the predators and prairie chickens. On the windy days Sections 1, 36, 6, and 5 were traversed. The weasel density ratings were 18, 32, 40, and 2.5, respectively. Four other sections did not provide signs of weasels; two were surveyed on March 15 (presumably mild), March 14 was stormy, and there were snow flurries on the afternoon of March 8. Evidently weasel tracks were not covered by drifting snow.

METHODS

The method of timber cruising by strips was adopted in principle, using four equally spaced strips per section; the first on the section boundary, and the third on the middle line. Thirteen sections were studied (Fig. 1). The party usually consisted of one counter and a compassman, although two counters were used at times. The com-

Table 1.—ESTIMATED ANIMAL POPULATIONS, WITH ACRES OF USED RANGE, ARGONNE DISTRICT, NICOLET NATIONAL FOREST, WISCONSIN, MARCH, 1934.

Section		Deer	Snowshoe Hare	Cottontail Rabbit	Ruffed Grouse	Prairie Chicken	Pileated Woodpecker	Red Squirrel	Porcupine	Beaver	Skunk	Weasel	Mink	Otter	Fox	Coyote	Wolf
	Cruise Factor	1	4	4	4	4	4	4	4	1	2	4	1	1	1	1	1
Unit A. Rolling upland, few large stands of mature timber; one stream with many beaver dams																	
36	No. seen	3	0	0	14			2	2			0	0			0	
	No. estimated	25	600	20	240			80	20			20	1			1	
	Acres of range	520	640	120	640			640	520			640					
	Acres per head	21	1.1	6	2.7			8	26			32					
30	No. seen	3	2	0	2		1	6	4	0							
	No. estimated	35	160	4	40		4	48	52	5							
	Acres of range	400	280	120	280		280	520	240								
	Acres per head	11	1.7	30	7		70	11	4.6								
29	No. seen	0	1		2			2	1				1			0	
	No. estimated	30	240		40			12	32				1			3	
	Acres of range	280	280		280			520	240								
	Acres per head	9.3	1.2		7			43	7.5								
20	No. seen	0	5		2			8	0			0	0	0	0		0
	No. estimated	150	560		64			40	8			8	5	1	2		2
	Acres of range	120	120		120			80	80			320					
	Acres per head	0.8	0.2		1.9			2	10			40					
19	No. seen	3	10		1	2	1	1	1	0		1		0	0		
	No. estimated	55	360		8	8	4	32	12	5		0		1	1		
	Acres of range	200	200		120	240	160	480	200								
	Acres per head	3.6	0.6		15	30	40	15	17								
Unit B. Many large open areas of recent burns near a large lake																	
2 E ½	No. seen	0	3	12	12			0	0		0				0		
	No. estimated	2	600	176	180			60	12		4				3		
	Acres of range	240	320	320	320			160	280		160						
	Acres per head	120	0.5	1.8	1.8			2.7	23		40						
1	No. seen	1	29	0	4			1	1	0		0		0		0	
	No. estimated	15	1160	16	56			64	24	2		36		2		3	
	Acres of range	320	320	160	320			400	400			640					
	Acres per head	21	0.3	10	5.7			6.3	17			18					
6	No. seen	5	6		1		1	1	4	0	0	0		0	2	0	
	No. estimated	50	560		160		4	60	20	4	2	8		1	7	2	
	Acres of range	100	260		200		120	320	320		200	320					
	Acres per head	2	0.5		1.3		30	5.3	16		100	40					
5	No. seen	9	1		13	2		2	4			0	0	0	1	0	0
	No. estimated	60	440		100	8		60	40			60	5	3	4	8	2
	Acres of range	80	200		80	240		400	100			240					
	Acres per head	1.1	0.5		0.8	30		6.7	2.5			4.0					
Unit C. Much open country, extensive muskegs, dense mixed hardwoods interspersed with cedar swamps																	
4	No. seen	9	9		8		1	0	5			0	0	0	0	0	
	No. estimated	80	360		100		4	52	64			8	2	1	2	4	
	Acres of range	160	240		120		160	580	160			640					
	Acres per head	2	0.7		1.2		40	11	2.5			80					
3	No. seen	6	0		7	0		0	6			0	0	0	0	0	0
	No. estimated	85	560		72	6		56	64			40	2	1	2	2	2
	Acres of range	100	320		80	240		480	80			640					
	Acres per head	1.2	0.6		1.1	40		8.5	1.3			16					
34	No. seen	3	5		6			3	0			0					0
	No. estimated	50	140		80			28	32			12					1
	Acres of range	200	240		240			280	200			240					
	Acres per head	4	1.7		3.0			10	6.3			20					
33	No. seen	2	6		3		3	4	1		0						
	No. estimated	20	80		28		12	36	24		2						
	Acres of range	100	200		100		100	240	100		140						
	Acres per head	5	2.5		3.6		8.3	6.7	4.1		70						

passman paced the mile distance in a straight line, usually tieing in at every marked quarter-corner; at section corners he usually had an error of less than a chain. The entire survey was done on snowshoes and as quietly as possible.

The counter moved 50 to 150 feet aside and ahead of the compassman, but they were always close enough together to see motionless animals between them. The counter tallied all animals seen, as well as tracks, beds, dens, and houses, always checking with a second counter, if present, on possible duplications. The compassman recorded the animals he disturbed only when certain that the counter had not tallied them. Where two counters worked, each counted only the animals and tracks that left the strip, allowing for duplication from one strip to another. For instance, if the track of a coyote had been crossed four times on adjacent strips, or even on two succeeding days, only one animal was recorded; one wolf track was crossed by seven successive strips.

A three-man party covered a maximum width of four chains or 264 feet, and a two-man party, three chains or 198 feet. The strips seldom exceeded two chains in width in a swamp, due to short visibility, even with a three-man party. In open cover a two-man party did as well as the three-man party, but in heavy cover two counters saw proportionately more animals than one. Use of a narrow and straight belt reduced the personal element of sampling to a minimum, making it possible to compare results from any two sections.

One counter would frequently range widely to inspect animal distribution. This was important, particularly with deer, which often used one end but not all of a cedar swamp, even before deep snow arrived.

The average daily cruising radius of each species was used as a basis for the census instead of an areal proportion. The area cruised in each section varied from 10 to 20 per cent. At the start and later in the survey when fresh snow made it possible, the writer trailed many individuals of various species to determine how far they had roamed during the night or the preceding 24 hours, and how much roaming occurred between dens and sets. An animal of short daily cruising radius would not have its tracks crossed by two adjacent strips, and in fact, might easily be missed, whereas those of long ranging species might be crossed several times.

Based on the extent of its daily cruising radius, each species (omitting small birds) was classified in one of four groups (cruise factors), depending upon whether the four strips were likely to reveal one-fourth, one-half, or all of the population in a section, thus:

1. Complete count (cruise factor, 1):
   A. Wide ranging: wolf, coyote, fox, wildcat, otter, and raven.
   B. Medium ranging: deer, mink, beaver, and muskrat, with special effort to cover all likely territory in which each might be found.
2. 50 per cent count (cruise factor, 2): skunk.
3. 25 per cent count (cruise factor, 4): snowshoe hare, cottontail rabbit, squirrel, porcupine, ruffed grouse, pheasant, prairie-chicken, weasel, and pileated woodpecker.

Deer were placed in Group 1 because cedar swamps were checked carefully. Mink, otter, and beaver were on streams where it was easy to make a complete cruise along the banks by always work-

ing upstream to an adjacent strip, and returning on opposite side. Skunks were put in Group 2 because they were roaming when the census was made. These classifications would change somewhat with the seasons, but were believed to give a fair picture of the conditions. As errors in this scheme are consistent over the 13 sections, population estimates for one section can be compared directly with those of another.

In the office the census strips were drawn over a cover map (scale, 4 inches per mile) of the section covered. The computed population of each species was the summation of its estimated frequency of occurrence in each of the several cover types sampled. The estimate for any species was never based on an assumed uniform distribution over 640 acres, nor on complete use of a particular cover type if field inspections revealed that the individuals were segregated within it.

The total population within a section was computed by multiplying the number of individuals estimated on four census strips by one, two, or four (the "cruise factors" in Table 1). The acres of potential game range were determined from an examination of the type map (an indispensable adjunct to the survey), but this figure was reduced wherever the survey indicated the species was not using all of its potential range. Next, the species population was figured on an acres-per-head basis, or density factor, by dividing the acres of game range by the estimated population. This quotient facilitated true comparison of the relative densities for any species.

For example, 50 snowshoe hares were tallied on four consecutive strips. Because of the short daily cruising radius of the species, this count is assumed to be one-fourth of the total. The cruise factor (4) times the number tallied (50) indicates 200 for the section. The type map showed 100 acres each of spruce-tamarack swampland and of adjacent mixed hardwoods in this section. The field men found hares distributed uniformly over the 100 acres of swampland but never entering to a distance of more than five chains into the 100 acres of hardwoods—equivalent to 20 acres according to the type map. Therefore, the 200 animals inhabited about 120 acres; hence, $120 \div 200 = 0.6$, the density factor for the snowshoe hare on this section. The 50 hares may have been tallied from 3 actually seen and 47 from signs. On two sections, no hare was seen, but the densities were calculated as 1.1 and 0.6, respectively, from signs alone.

The density ratings for 7 species are summarized in Table 2. The uniformity of the results for many animals indicates that the field men were rather consistent in their allotment of a certain number of tracks as being made by one individual.

COMMENTS ON SPECIES

Deer. The estimated population varied from 2 to 150, and the densities from 20 to 0.8; eight congested areas had densities of 0.8 to 5.0. The total estimated number is probably a residual population. In summer deer spread into more areas, but 5 to 20 per cent of those sections are in muskegs which have low forage value for deer. Sec. 32 is mostly muskeg, containing a few small islands of timber on which no deer were found although a few tracks were seen adja-

Table 2.—RELATIVE POPULATION DENSITIES IN ACRES-PER-HEAD.

Section	1	36	2	6	5	4	3	29	30	19	20	34	33
Deer	21	21	120	2	1.1	2	1.2	9.3	11.4	3.6	0.8	4	5
Snowshoe Hare	0.3	1.1	0.5	0.5	0.5	0.7	0.6	1.2	1.8	0.6	0.2	1.7	2.5
Cottontail Rabbit	10	6	1.8	—	—	—	—	—	30	—	—	—	—
Red Squirrel	6.3	8	2.7	5.3	6.7	11	8.5	43	11	15	20	10	6.7
Porcupine	17	26	23	16	2.5	2.5	1.3	7.5	4.6	17	10	6.3	4.1
Weasel	18	32	—	40	4.0	80	16	—	—	—	40	20	—
Ruffed Grouse	5.7	2.7	1.8	1.3	0.8	1.2	1.1	7.0	7.0	15	1.9	3.0	3.6
Date of Survey, March	6	7	8	9	12	13	14	14	15	15	16	16	16
Temperature °F., 7 A.M.	0°	0°	5°	5°	18°	32°	2°	2°	26°	26°	Thawing		

cent to Secs. 5 and 29. Summer areas that average 50 deer per section when all parts are producing food are considered as very good country. This winter population indicates such numbers existed if one accepts these data. Many deer yards had a deer line six feet high, but in others it was low. Frequently a cedar swamp a mile long might have an area or two of perhaps twenty acres overbrowsed and the remainder untouched. Many areas were impenetrable for deer in late winter because of deep snow, but had been accessible in late fall when deer started to congregate. The periphery was often used much more heavily than the interior. The few dead deer found at this time were usually ascribed to poachers or predators.

Snowshoe Hare. These animals evidently were at or past their peak of abundance. In driving along the roads at twilight in May about one-tenth as many were seen in 1934 as in 1933. The density (Table 2) varied from 0.2 to 2.5; most of the density figures (8 of 13) are from 0.2 to 0.7 with the next at 1.1 and 1.2. Whether estimating by signs gives too high or too low a figure, the animals seemed to have been more or less uniformly distributed over all their habitat in the territory surveyed.

The field notes indicate that hares were confined to swamps and their margins. In Sec. 2, they were abundant on high land in pine-hemlock with underbrush of scattering density. In Sec. 3 rabbits chewed young spruce and other brush. On March 25, tracks were more than four times as numerous in the alder-spruce type than in the upland hardwoods. Tracks were also found in semi-open stands of pine and hemlock containing a mixture of maple and yellow birch. Cursory examination of 19 hares taken by snares on March 12 and 13 showed many with a few tapeworm cysts, but the livers appeared normal.

Cottontail Rabbit. The densities were 1.3, 6.0, 10, and 30 acres per head, indicating variable distribution. Cottontails were found only where there was open and upland country. Their tracks were seldom in the habitats used by snowshoe hares. Their reaction to snaring was quite different. A cottontail caught in a snare became wildly frantic and either choked itself immediately or broke the wire, whereas a hare often was found the following morning sitting with the noose slack around its neck.

Ruffed Grouse. Efforts were made to distinguish old and new tracks, and those of birds flushed from others. Some densities were astoundingly high and others quite reasonable. The density figures are somewhat similar to those for snowshoes; on 8 of 13 areas they were

0.8 to 3.6, indicating a high population. Tracks counted on two strips one-quarter mile apart could have been made by the same birds, but it is believed that the chances of duplication were rare. The one grouse found dead had a broken neck.

Prairie Chicken. These were noted in only three of the 13 sections. They were flushed in rather open country and invariably flew off a quarter to half mile to alight in the tops of hardwoods. Since the observers had to be within 50 yards to flush them, they were put in the group of 25 per cent count.

Pheasant. As the area surveyed is near the northern limit of pheasant range in northeastern Wisconsin, only one group was found, at the edge of farming country near Virgin Lake, in the extreme southwest.

Pileated Woodpecker. Fresh work was rare but the birds were seen in five sections. Being difficult to see, they were included in the 25 per cent group, although their drumming could be heard at a distance of 10 chains when wind was not interfering.

Squirrels. The red squirrel was distributed over more area in each section than any other animal (Table 1). Its density varied from 0.5 to 43 acres-per-head, the commonest densities being 5 to 8 acres-per-head in 6 of 13 sections.

Grey squirrels were reported from Secs. 20 and 2, but none was seen. Their tracks were definitely larger than those of red squirrels, making the chance of confusion slight. The animals were scarce, but may have denned up with temperatures near 0°F. on several mornings.

Porcupine. These were abundant as very few people had been in the region following logging except a few deer hunters and occasional trappers. The field men saw porcupines in all but two sections. The density varied from 26 to 1.3 acres-per-head. A complete cruise count of porcupine in the winter is relatively easy, as their trails are conspicuous and, when they feed in trees, the snow is littered with chips. They may stay in a large tree top for a week when trails could easily be missed, but only a heavy snow will obliterate a porcupine trough.

During March, 19 were shot, including 6 pregnant females, 3 small females, 5 males, and 5 not classified. The fetuses were fully haired, with quills, and gasped for air following caesarian operations. Of 11 recorded as to cover type, 2 were in white pine, 2 in maple, 1 in balsam fir, 2 in hemlock, and 4 on ground under overturned stumps.

Beaver. No beaver was seen; there was one large house in each of four sections. The numbers were recorded on the basis of the size of houses observed. One in Sec. 19, on 4-Mile Creek, was large enough for 6 beaver, and another in Sec. 30, on Bailey Lake, for 4 beaver. All streams were cruised between strips for a full check on houses, but some may have been missed due to deep snow. There were numerous dams on 4-Mile Creek in Secs. 19 and 20 and much of the area was flooded.

Muskrat. One was roaming through open country at least a mile from water. On March 14, another was trailed on crusted snow through an old burn, over a mile from water; it entered every woodchuck hole encountered.

Skunk. A few individuals had just started to roam after their winter sleep; on March 3 one skunk had come out of

its den, walked two feet away, and returned.

Weasel. The tracks were scattered. These animals are travelers, yet from following many trails it seemed that each stayed within a 40-acre area. Their trails were commonest in brushy country, and absent in swamps. Five sections lacked tracks. The solitary record in Sec. 19 was of a dead animal found on a stump. Their densities seem to be about one per 30 acres. The extremes of 4.0 and 80 seem unnatural, yet were in adjacent sections (5 and 4). Their abundance may have been an indication of meadow mouse abundance, and therefore an index of comparative mouse damage to recently planted trees beneath the snow.

Mink and Otter. A few were found along the beaver ponds and the large lake in Sec. 6. One or two otters possibly made trails in more than one section. The count for mink was considered as complete since care was taken to examine the full length of each stream.

Bobcat. Tracks were seen only on Sec. 34 where a family of 4 was indicated. The animals were apparently very scarce.

Fox, Coyote, and Wolf. Foxes were reported from 8 widely scattered sections; one peg-legged animal was trailed in Secs. 1 and 2. Coyotes were reported in 5 sections, undoubtedly duplicates. One pair of wolves crossed Secs. 34 and 3.

On March 25, a pair of foxes ran south through Sec. 34. In some places one trailed the other, frequently stepping in the same tracks, but at times they ran shoulder to shoulder, leaving trails not over six inches apart. Evidence of similar behavior was also seen on March 16.

Similar trailing of one animal by another also was seen with wolves. A week or two after the survey a wolf trail was followed about half a mile through open country interspersed with clumps of dense brush. Then a second parallel trail was seen about 25 yards away. On back-tracking, this trail was seen to separate from the first in some shrubs. Upon following the two ahead for about 200 yards the second trail again merged with the first, and close inspection for some distance failed to show signs of two animals, so carefully did the second use the footprints of the leader. The snow was light and the tracks about six inches deep.

During the survey the observers were puzzled to find a single wolf trail on one or two strips, then two trails on the next strip, and again only one. The second animal may have been trailing the first. One family of five wolves was believed to be using the area.

Raven. Many birds were seen after the snow left, but only one pair was reported in March.

BELT TRANSECT VS. CRUISING RADIUS

Since 15 per cent of the land area was cruised, it might seem logical to compute the total number of animals from the individuals seen on this 15 per cent, and compare this estimated total with that from the method actually used. In the absence of cover maps of the area, computations by the belt transect method could not be used. The per cent of cruise of any cover type *must* be known, from which, by proportion, its total amount may be estimated. The summation of populations for each cover type inhabited would give the total estimated number of individuals for the section.

On a rectangular area 15 by 45 chains, a 3-chain width lengthwise

through the area would cover 3/15ths, or a 20 per cent cruise, whereas a 3-chain width across the area would cover only 3/45ths or 6⅔ per cent of the area. Thus total populations cannot be computed in the absence of a detailed cover map of the area surveyed.

COST

Winter work on snowshoes had its advantages in a region of muskegs and mosquitoes. A party averaged a section in six hours. At a labor cost of $0.35 per man-hour, a two-man party cost $4.20, and a three-man party cost $6.40 per day; and a section could be cruised at a cost of one cent per acre. In localities with few swamps, one party could cruise two sections in eight or nine hours, but the distance to an area from a road had to be considered in planning a time schedule. The total cost was 43.5 man-days of C.C.C. labor and 15 man-days of technical labor to cover nearly 11 square miles. Of the C.C.C. time charged to the project, 17.5 man-days were spent in training and 26.0 in actual field work.

CRITICISM OF METHOD

The method used in this survey is believed to have a place under such conditions as described. Two counters are better than one, especially when they work ahead of the compassman. This makes a "pocket" for many rabbits to run back into and be seen easily by the other counter or compassman. Light fluffy snow makes for the quietest travel and helps to indicate the age of tracks. A great weakness in this type of survey lies in the fact that much of the population was estimated from signs. Four persons made estimates, and the personal factor therefore enters. The grouping of the results for the various species into such small ratios of spread (0.2 to 0.6 for snowshoe hares, 0.8 to 3.0 for grouse) seems to indicate that the estimates of numbers were as close as could be expected in a two-week survey that started with untrained men. Whether the acres-per-head density on this survey is too high or too low, there is no way of knowing.

SUMMARY

A game census in Nicolet National Forest, Wisconsin, in March, 1934, entered 13 sections in 10 days of field time, using 26 man-days of C.C.C. labor and 15 man-days of technical labor. The area had interspersed cover types, varying from burns and muskegs to mature timber.

Four strip censuses were made in each section. Animals were tallied as seen and as estimated from tracks and other signs.

The species were classified into four groups based on their respective daily crusing radii as determined from tracking during the time of survey.

Snowshoe rabbits were numerous and almost uniformly distributed over their preferred habitats in a density of one or two per acre.

Ruffed grouse on 11 of 13 sections averaged more than one per four acres.

The red squirrel was the most widely distributed species.

This type of survey depends upon the ability of technicians to estimate correctly the numerical abundance of several species of animals from signs alone; it gave surprisingly close results for several species.

A cost of one-half to three-fourths cents per acre surveyed may be expected with experienced men.

MOVEMENT OF TROUT IN CONVICT CREEK, CALIFORNIA[1]

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A study of upstream and downstream movements of "resident" trout was begun at the Convict Creek Experiment Station in 1940 by means of a two-way fish trap. This station is operated by the U. S. Fish and Wildlife Service in cooperation with the U. S. Forest Service and the California Division of Fish and Game. It is on the eastern slope of the Sierra Nevada, forty miles north of Bishop, California, at an elevation of about 7,200 feet.

The Drainage Basin

Convict Creek is one of the principal tributaries of the Owens River in eastern California. Its basin drains eastward of the main Sierra Nevada escarpment and like most eastward running streams, has a fairly constant flow with slight fluctuations in volume.

The creek rises at an elevation of about 11,000 feet, drops some 4,000 feet in the eight miles to the Station, thence it flows about four miles with 400 feet of fall to enter the Owens River. The stream passes through four lakes in its course and six others lie on tributaries at elevations of over 9,000 feet. A dam was completed by the City of Los Angeles at the head of the Owens River Gorge in 1941 so that Convict Creek now flows into Lake Crowley, the reservoir formed back of the dam, four miles below the Station. The lake filled late in 1941.

[1] F. H. Sumner and Douglas Mottley, temporary assistants, helped in this study.

The Owens River basin was originally barren of trout, but Lake Tahoe cutthroat (*Salmo henshawi*), rainbow (*Salmo gairdnerii*), eastern brook (*Salvelinus fontinalis*), golden (*Salmo aguabonita*), and brown trout (*Salmo trutta*) have been planted. Brown trout predominate in Convict Creek below Convict Lake, and comprise more than 98 per cent of all trout caught by anglers. Rainbows have been planted in Convict Lake for the past seven years and now predominate in catches from the lake. Accessible only by trail, the high lakes provide excellent angling for golden and rainbow trout. Eastern brook trout are rare.

The Trap

The trap was located at the upper end of the experimental area, about one and a half miles below Convict Lake, at concrete flood control works constructed several years previously to divert high water around the area. The concrete apron and central pier of the diversion works afforded an excellent location for the trap built in early April, 1940 (Pl. 9).

The trap was made of redwood pickets with ½-inch spaces between. Earlier studies of picket spacing compared to width of fish showed that ½-inch spacing would permit fish approximately 4 inches long and smaller to pass through. Actual operations proved, however, that such spacing stopped very few fish under 4½ inches long. Lack of funds prevented construction and operation of

screen-wire traps for taking fish of all sizes.

The trap was tended each morning and evening. The fish in the trap were weighed, measured, marked, and then released in the direction in which they were travelling when caught. In 1940 the trap was operated 223 days from April 13 to November 22, and in 1941, 199 days from April 27 to November 12.

Table 1.—TROUT MOVING IN CONVICT CREEK.

APRIL 13 TO NOVEMBER 22, 1940

	Total Number	*Percentage*	*Length in inches Average*	*Range*
DOWNSTREAM				
Brown	457	96.6	6.1	4.6–17.6
Rainbow	17	3.4	14.0	5.7–17.2
Cutthroat	0	—	—	—
Eastern Brook	0	—	—	—
Total	474			
UPSTREAM				
Brown	77	87.5	7.0	4.4–17.0
Rainbow	7	8.0	10.1	5.5–15.2
Cutthroat	3	3.4	14.8	5.4–19.6
Eastern Brook	1	1.1	—	9.8
Total	88			

APRIL 27 TO NOVEMBER 12, 1941

	Total Number	*Percentage*	*Length in inches Average*	*Range*
DOWNSTREAM				
Brown	144	86.2	6.5	5.2–15.4
Rainbow	22	13.2	10.7	5.6–18.1
Cutthroat	1	.6	18.2	—
Eastern Brook	0	—	—	—
Total	167			
UPSTREAM				
Brown	32	91.4	7.2	3.4–17.3
Rainbow	3	8.6	12.0	11.2–13.0
Cutthroat	0	—	—	—
Eastern Brook	0	—	—	—
Total	35			

Little is known about the movements so so-called "resident" stream trout save that they move upstream or into tributaries to spawn. Cobb (1933) in Connecticut, from the results of tagging adult, hatchery-reared, brown trout with internal tags, stated that 66.5 per cent were caught in the same portion of stream where they had been planted, 6.8 per cent were found upstream, and 26.6 per cent had migrated downstream. He says (p. 310): "... brown trout should be planted where a run downstream will place them in a good body of water rather than in a polluted stream." Cobb did not say how far the planted brown trout had migrated in any instance, nor is the term, "portion of stream," clearly defined. Cobb's work was concerned solely with migrations of trout planted from hatcheries, but Shetter (1938) has presented data on the movements of resident fish populations obtained from the operation of a two-way fish trap in Canada Creek, Michigan. As to the movements of brown trout, Shetter says (p. 335): "There seemed to be no spawning run of brown trout during the fall months of the year, but there was a small but noticeable run upstream during the month of July."

KINDS, NUMBERS, AND SIZE OF TROUT TRAPPED

The most significant observation from the trap operation was to find a fairly heavy downstream movement of brown trout each spring, with a peak in late May (Table 1). In 1940 a total of 474 trout were caught in the downstream section, mostly brown trout and a few rainbows; no cutthroat or eastern brook trout was taken. The 88 taken in

the upstream section were predominantly brown trout.

In 1941, trap operation yielded 167 trout in the downstream trap and 35 in the upstream trap; brown trout predominated in both cases. No golden trout was taken at any time.

Population studies, made in Convict Creek near the end of April each year by pumping certain sections of stream dry, have always revealed the presence of many recently emerged brown trout fry. Their average total length is around 1 inch, and they pass easily through the ½-inch spaces between the pickets.

The downstream movement in 1941 was only 35 per cent as great as in 1940, and the upstream movement in 1941 was but 39 per cent of that in 1940. This could have resulted either from reduction of the population or lack of movement in 1941. The species and size composition of the fish trapped, however, remained quite similar. The data presented here agree with Shetter (1938) in that no fall spawning run upstream was observed, but the absence of a run of brown trout upstream in July in Convict Creek is at variance with his findings from Canada Creek, Michigan. Likewise Shetter did not report any pronounced downstream migration of brown trout in the spring as is reported here.

The best trout spawning areas in Convict Creek lie downstream from the location of the fish trap, although fairly good areas exist above. Many brown trout have been observed in spawning activities both above and below the trap but the greatest number are usually seen in the first few miles above Lake Crowley. In view of the presence of excellent spawning areas below the trap, it is not surprising that no fall upstream spawning run of brown trout was noted.

High water during parts of the 1941 field season necessitated removal of the trap for a total period of 26 days. As trout catches in the trap were practically zero for two weeks before removing the trap and for two weeks after replacing it, the catches lost during this period are not considered significant.

The brown trout caught in the downstream trap averaged 6.1 inches in total length in 1940, and 6.5 inches in 1941. In 1940 the average total length of brown trout caught moving upstream was 7.0 inches and in 1941, was 7.2 inches (Fig. 1).

TIME OF MOVEMENT

During the 1940 season, the greatest downstream movement was from May 4 to May 25, with the peak during the week of May 11 to May 18 (Fig. 2). The upstream movement showed no significant peaks, the rate of movement being quite uniform over the entire operating period.

In 1941, the greatest downstream movement was from May 4 to May 26 (Fig. 2) with the peak from May 11 to May 18. This coincides perfectly with the peak movement during 1940. Likewise the upstream movement in 1941 had a character very similar to that in 1940, except for a slight increase in the rate of movement during the week of November 2 to 9.

Rate of movement did not seem to be especially influenced by either water temperatures or volume of flow. Daily mean water temperatures for 1940 and 1941 are shown in Figure 2. In 1940, water temperatures for May ranged between a minimum of 40.5°F. and a

Convict Creek Experiment Station. Upstream face of fish trap in flood diversion works. Two picket sections at left form the upstream and downstream sections respectively, of the trap. Picket section at right prevents fish from passing down the flood diversion channel.

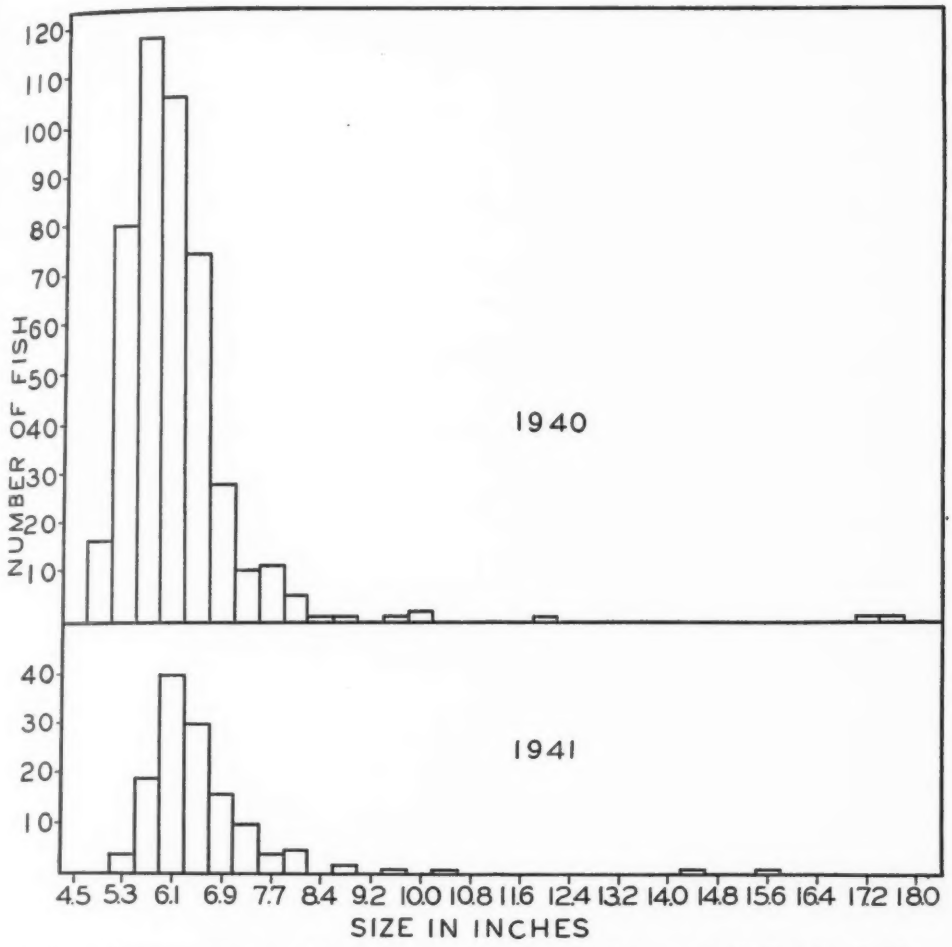

Fig. 1. Size and number of brown trout taken in downstream trap in Convict Creek.

maximum of 60.5°F. with a monthly mean of 51.6°F. In 1941, they ranged between 40.0°F. and 60.0°F. with a mean of 49.8°F. in the same month. In both 1940 and 1941, the greatest numbers of brown trout running downstream were taken in the week of May 11 to 18 some three months before maximum seasonal water temperatures were reached in August.

Water flow[2] for Convict Creek in 1940 ranged from a minimum of 15.7 second feet on May 7 to a maximum of 90.6 second feet on May 26 (Fig. 2). In 1941, minimum flow occurred on May 1 at 15.8 second feet and the maximum on May 27 when 67.4 second feet was re-

[2] From records obtained by the Los Angeles City Department of Water and Power approximately one mile upstream from the Convict Creek Station. No tributaries flow into the main stream between the gaging point and the station, so flow at both places would be approximately the same.

ported. Peak discharge in 1940 was 110.3 second feet on June 18, and in 1941, 145.0 second feet reported on June 17 (Fig. 2). It would appear only natural that each year the peak of downstream movement of brown trout coincided with rising, but not peak, flood waters.

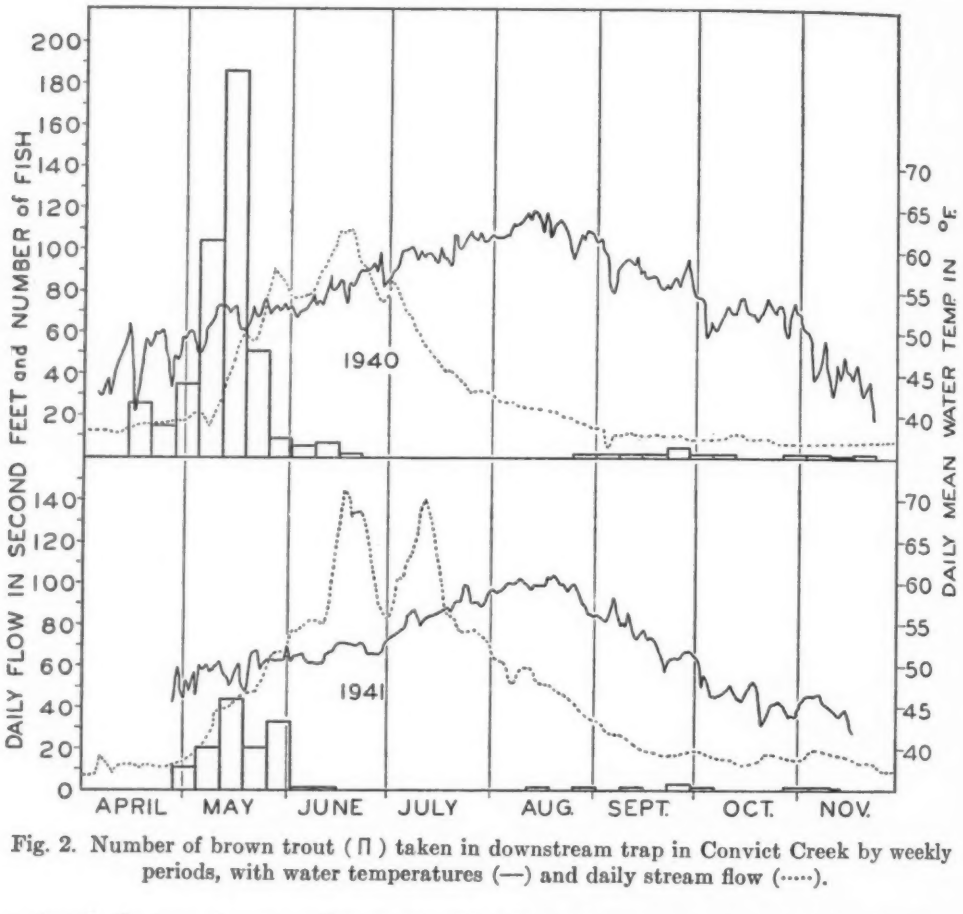

Fig. 2. Number of brown trout (⊓) taken in downstream trap in Convict Creek by weekly periods, with water temperatures (—) and daily stream flow (·····).

The 22 rainbow trout caught in the downstream trap during 1941 were nearly all taken by June 11. Some were large spent females. Nearly all were a bright, silvery color with loose scales indicating that they may have come downstream from Convict Lake, about 1½ miles upstream from the trap. From 1938 through 1941, inclusive, the California Division of Fish and Game planted a total of 91,980 good-sized rainbow trout in Convict Lake. These plantings seem to have been highly successful for the predominant catch has changed from brown trout to rainbow and the fishing has materially improved.

It is a common belief that rainbows do not migrate out of lakes to any extent if conditions are suitable, although rainbows planted in streams often show

a strong tendency to migrate downstream for considerable distances. In the eastern United States, plants of rainbows in suitable lakes generally have been successful regardless of barriers across the outlets. From the evidence presented here there was but limited downstream movement of rainbow, at least during the period of trap operation—7.4 months in 1940 and 6.6 months in 1941. It is possible but not likely that rainbows migrated down Convict Creek during the winter when the trap was not in operation; there seems to be little winter movement of resident inland trout.

A few rainbows, however, occasionally migrate downstream from Convict Lake as proved in 1935. A plant of 2,014 marked rainbows averaging 5.67 inches in length was made in the lake on July 20; 349 were taken in the lake, but only eight were caught later in the creek below (Needham, 1937). Of the latter, one was captured in July, five in August, and two in September. None was taken more than one-half mile below the lake. There was no evidence of a mass exodus.

Since rainbow trout predominate in Convict Lake, the brown trout captured while moving downstream must originate from the stream, and their migration might be due primarily to conditions in Convict Creek. The mile and a half of stream between Convict Lake and the trap is largely of swift water with some low falls and short steep riffles, but few deep pools. Food is poorer than in the meadow-like reaches below the trap and adequate shelter may be lacking; possibly the brown trout, after becoming about 6 inches in length, no longer find conditions satisfactory and move downstream to seek waters affording more food and shelter.

Whether or not the downstream movement of brown trout in Convict Creek is peculiar to that drainage and its ecological conditions remains to be determined. The facts reported from trap operations through two partial seasons indicate a pronounced downstream movement; if this occurs annually it will have definite practical bearing on the stocking of brown trout. The distance of downstream movement should be determined by operating a series of traps and marking the fish at an upper trap for recognition when caught later in traps located farther downstream.

Many animals migrate between feeding and breeding areas and the downstream movement of brown trout possibly is associated with lack of food or shelter or both in the upper waters. The movements occur largely in May and mostly involve fish in their second year while sexually immature, contradicting the idea that the run is associated with spawning. Furthermore, no comparable fall upstream movement was observed.

In Europe, brown trout run to the sea and downstream movements of our trout of this species may result from this age-old instinct. Downstream migrations of young rainbow trout have been similarly explained. Possibly the downstream movement results from a combination of the space factor combined with the necessity for seeking areas offering better food and shelter.

SUMMARY

Movements of trout were studied in Convict Creek, California through the use of a two-way fish trap, from April

into November, in 1940 and 1941.

A heavy spring downstream movement of brown trout (*Salmo trutta*) was observed; 457 of 474 trout taken in the downstream trap in 1940 were of this species, as were 144 of the 167 captured there in 1941.

Only 17 rainbows were trapped moving downstream in 1940, and in 1941 22 rainbow trout and 1 cutthroat trout were taken.

Comparatively few were trapped moving upstream in 1940, when a total of only 88 were taken of which 77 were brown trout. In addition, 7 rainbow trout, 3 cutthroat and 1 eastern brook trout were taken enroute upstream. In 1941, only 35 trout were taken going upstream, 32 brown and 3 rainbow.

The average total length of downstream brown trout was 6.1 inches in 1940 and 6.5 inches in 1941.

The peak of downstream movement occurred each year in the week of May 11 to 18.

The peak of downstream movement coincided with rising but not maximum stream flows. There was no apparent correlation between trout movements and water temperatures.

Most of the brown trout composing the downstream migration were sexually immature, and it is assumed that the downstream run is not associated with spawning. Lack of adequate food and shelter in the upper reaches of the stream may be important factors in initiating the movements.

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PRODUCTION OF TROUT IN A SMALL ARTIFICIAL POND IN WESTERN OREGON[1]

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Observations of planted fish in an artificial impoundment in western Oregon from May, 1938, to December, 1941, indicate that trout may be produced successfully on certain types of farm land. In the small valleys and foothills of the Coast Range many farms have adequate water supplies and suitable topography on which small impoundments could be constructed for raising fish. The production of fish in small ponds or reservoirs without arti-

[1] Technical Paper No. 404, approved by Director, Oregon Agricultural Experiment Station. Contribution of the Department of Fish and Game Management cooperating with the Oregon State Game Commission.

Verne McDaniels, Superintendent of the State Forest Nursery, cooperated to make this work possible. Several students of the Department of Fish and Game Management assisted in planting and recovery and in tabulating the data.

ficially feeding is not new. Gasch (1880) discussed pond-fisheries and the farming operations connected therewith. Embody (1915) has discussed the possibilities of the farm fish pond. Schaperclaus (1933) outlined the principles and practice of practical production of fish in ponds in Germany. More recently Swingle and Smith (1941) have noted the possibilities of farm ponds, particularly for the warm water or spiny-rayed fish in the southeastern United States. Recent work by Hey (1941) in South Africa has likewise indicated the value of small pond production of fish.

Few data are available as to what may be expected from small water areas in the northern and western states, with particular reference to salmonoid fishes, where such waters are often used as water reservoirs for small irrigated farms. Such areas offer opportunities for both profit and recreation. To stimulate interest and to provide a guide for further researches on this type of nattural production for trout, workers at Oregon State College in cooperation with the Oregon State Game Commission have for the past 3½ years determined the productivity of a small artificial lake near the College.

THE POND

Cronemiller Pond, of 2.75 acres, was built in 1937 by C.C.C. labor to furnish water for a forest nursery in McDonald Forest about 7 miles north of Corvallis, Oregon. It was formed by a rock-faced earthen fill across a U-shaped depression on the slope of a forested hill above the nursery. An 8-inch pipe brings water 300 yards from a small stream. Under normal conditions about 80 gallons of water per minute enters the pond, but during late summer the amount is 10 to 30 gallons per minute. A 5-inch pipe drains the pond. Eight to 10 days are required to fill the pond and approximately 32 hours are needed to drain it, leaving a pool 50 feet long, 18 inches deep, and 6 to 12 feet wide.

When filled, the lake has an average depth of 8 feet, and a maximum of 22 feet. Except for the rock face of the dam, the bottom is of clay and mud in the deepest area and of humus and clay loam in the shoals and periphery. Cat tails (*Typha latifolia*) grow in profusion around one-third of the lake and the water weed (*Elodea*) is rapidly becoming a pest in the shallower portions. The water is soft, the following analysis being typical (October 1, 1941): temperature 61° F., oxygen 9.2 parts per million, carbon dioxide 4.5 p.p.m., methyl orange alkalinity 63.00 p.p.m. $CaCO_3$, pH with glass electrode 6.7.

PRODUCTION OF FOOD ORGANISMS

In the first year after construction little attention was paid to the insect population. When the first fish were planted (1938) insects appeared to be as abundant as in similar natural lakes in this region. Eckman dredge samples in 1939 showed the deeper waters to have a heavy population of dipterous larvae. Ten samples representing 2.5 square feet revealed the following population: Diptera, 191; Ephemerida, 13; Odonata, 2; Hemiptera, 3; and Mollusca, 4. Stomach analyses of 18 trout taken during the winter of 1940 showed the following numerical incidence of invertebrate food organisms: Diptera, 1,351; Odonata, 20; Hemiptera, 25; Coleoptera, 2; and Mollusca, 3. Fluctuating water levels produced no appreciable

decrease in invertebrates, since the lake was not left drained over an extended period and draining was done during periods of high humidity or precipitation.

FISH PLANTING HISTORY

The pond remained without fish for about a year after construction. Plantings were then made with the idea of providing recreation and later the pond was used for special studies by advanced students.

The first planting, on May 6, 1938, consisted of 128 rainbow trout (*Salmo gairdnerii*), and 33 Loch Leven trout (*Salmo trutta*). Because of incomplete recovery of the 1938 plant and the consequent residual population present at the time of the 1939 plant, accurate analyses of data relative to survival and increment for the original plant are not possible.

All fishes of the first stocking were approximately one year old at time of planting and weighed a total of 14,080 grams (31.1 pounds). On March 2, 1939, 13 rainbow trout and two Loch Leven were recovered. The weight increment, based upon those recovered, was 352 per cent for the rainbow and 498 per cent for the Loch Leven up to March, 1939.

The same stock from which the above planting was made was maintained during this time in ponds at the Alsea Hatchery. When it became evident that a stocking of 161 fish of this size did not utilize the productive capacity of the pond, a second plant of 45 Loch Leven and 255 rainbow was made on March 23, 1939. These were all numbered with Monel-metal tail-tags.

Data relative to these plants are presented in Table 1. On the basis of 15 fishes recovered from the first planting the fish in the pond made a better growth than those retained in the hatchery during this period of 10 months (305 per cent gain in weight in the hatchery against 352 per cent in the pond).

Table 1.—RECORD OF FIRST TWO PLANTINGS IN CRONEMILLER POND, OREGON.

Species	Date planted	Number planted	Mean weight (grams)	Mean length (cm.)	Date recovered	Number recovered	Months in pond	Mean weight (grams)	Mean length in (cm.)	Per cent gain	
										weight	length
Rainbow	May 6, 1938	128	106.3	20.0	Mar. 2, 1939	13	10	480.4	34.0	352	70.0
Loch Leven	May 6, 1938	33	74.8	18.2	Mar. 2, 1939	2	10	448.3	34.7	498	90.6
Rainbow	Mar. 23, 1939	255	324.6	30.9	Mar. 7, 1940	72	12–22	515.0	34.2	59	10.7
Loch Leven	Mar. 23, 1939	45	206.0	29.2	Mar. 7, 1940	10	12–22	372.0	34.1	80	16.7

On March 6, 1940, the pond was partially drained and the remaining water poisoned with cresol according to the method of Embody (1940). Eighty-six fish were recovered, weighed, and measured. On the following day derris was applied for complete removal of the fish population; during the following 2 days 44 additional fishes were recovered or 130 in all. Some may have resulted from the first planting. As the pond was not protected or the outlet screen permanently in place and the fact that only 11 tags were recovered, the only information available for analysis is that of growth (Table 1).

Of the 86 rainbows recovered on March 6, 33 were liberated in the stream adjacent to the inlet pipe. Their phys-

ical condition indicated readiness to spawn and suitable spawning areas existed at the point of liberation. No consideration then was given to the possibility of resulting fry returning to the lake by way of the screened inlet pipe. In May and June rainbow fingerlings were recovered for a distance of one mile downstream from the point of liberation of the adult fish in March. It was not until samples were taken of the subsequent plant that the return of a portion of the rainbow hatch to the lake was known.

On September 27, 1940, 300 coastal cutthroat trout (*Salmo clarkii clarkii*) were liberated in the pond. A representative sample of 25 additional specimens was retained for studies on comparative growth and morphology. The pond was closely observed at frequent intervals from the time of planting to watch for mortality. One fish was recovered on January 30, still alive but in a listless condition. Careful examination failed to reveal the cause. No actual predation was observed, although a great blue heron (*Ardea herodius*) was repeatedly observed near the pond throughout late summer and early autumn. Beginning in January, 1941, samples were taken by angling (fly fishing only) at frequent periods to ascertain the condition and rate of growth of the fishes and the return per angling effort. On December 10, 1941, the pond was drained and recovery made of all remaining fishes. Derris root containing 5 per cent rotenone, was applied to the residual water to insure complete recovery; 102 cutthroat, and 217 rainbow, were obtained. The total recovery of cutthroat trout from the time of planting, therefore, was 214 or a survival of 71.3 per cent. The total number of rainbows taken was 251, but since no record was available for the original number, survival data cannot be recorded (Table 2).

Table 2.—RECOVERY OF CUTTHROAT AND RAINBOW TROUT.

	Cutthroat	*Rainbow*
Planted	300	?
Caught by angling	112	34
Recovered by poisoning	102	217
Total recoveries	214	251
Percentage survival	*71.3*	—

By recording data from each sample taken during the period of study, the rate of growth, condition, and return per angling effort could be determined.

Table 3.—RESULTS OF PLANTING CUTTHROAT TROUT, SEPTEMBER 27, 1940 TO DECEMBER 10, 1941.

Date	Number in sample	Mean weight (grams)	Weight increment per cent	Mean standard length (cm.)	Length increment per cent	Return per hour angling
September 1940	25	10.3	—	8.64	—	—
January 1941	6	33.6	*226.2*	13.89	*60.8*	3.0
April	11	57.1	*69.9*	16.70	*20.2*	3.0
June and July	13	94.2	*64.9*	19.55	*17.0*	2.7
October	71	98.3	*4.3*	19.60	*0.2*	2.0
November	11	96.0	*−2.3*	19.80	*1.0*	0.5
December	102	113.6	*18.3*	19.61	*−1.0*	
Total gain (14.5 months)			*1,002.9*		*127.0*	

This is shown for cutthroat trout in Table 3. The samples of rainbows taken were inadequate for analysis.

Samples obtained by angling were not of equal number, but subsequent comparison of specimens taken indicated the samples to be representative in all instances except for November. This group when compared with previous samples as well as the last sample taken showed a loss in weight. The inadequacy of the sample, the effect of several months' fishing, the use of artificial flies only, and the selectiveness of the points fished probably had a bearing on the apparent loss in weight shown by the November sample.

The percentage gain in weight, when broken down into the six sampling periods, shows that the fish grew very rapidly during the four autumn and winter months. September cannot be included as a period of growth as planting was not made until September 27. From the time of planting until November, a year later, a steady increase in weight was exhibited; this decreased rapidly in magnitude during the last three months. The total mean weight-increment amounted to 103.3 grams per fish (0.2 pound) or 1,002.9 per cent. The periodic length increments show a similar trend of rapid growth during the first eight months after planting, following which there was a leveling off of length increase significantly greater than for the weight The total mean length gain for the period was 10.97 centimeters (4.2 inches) or 127.0 per cent.

Since each fish removed from the pond was weighed individually to 0.1 gram, accurate poundage data may be determined. Based upon actual weight of the fish at the time of removal, the total weight of all fish in the pond was 134.6 pounds. The weight of fish planted was 6.5 pounds. The poundage production for the period was therefore 128.1 pounds. The total cutthroat poundage was 48.8, and that for rainbows was 85.8. The production during 14.5 months represents 46.5 pounds per acre for the 2.75 acres of water surface. A conservative market value of trout of this size is $0.50 per pound and on this basis the fish taken from the pond were worth $67.30. The value of these fish for recreational purposes is more than their market value.

With respect to the return per angling effort, the apparent importance of population density in relation to angler success is of interest. Starting with a population density of at least 169 fish per acre the return per angling effort began to drop off while the number of fish was still approximately 158 per acre, and maintained this decline to a low of 0.5 fish per hour angling while the population density dropped to only 132 fishes per acre. Past fishing effort and selectiveness of points fished no doubt contributed to the wariness of the fish. Climatic and limnological factors are known to influence profoundly the catchability of game fish but were not measured. The minimum population density which will produce satisfactory angling, however, is not well known. It is considered significant that a population density in excess of 100 fish per acre was necessary to produce a satisfactory angling return of 2.0 fish per hour in October, a month when fishing in this area is considered good. If such density is necessary for good fishing, the factor becomes important in lakes of

large area or low food production. Under the conditions in this pond, it is believed that fly fishing was more selective of cutthroats than rainbows. The number of rainbows caught on flies is much lower than that of cutthroats so caught (Table 2), as borne out in three instances. While making a series of bottom samples from a boat, a fly was cast from the stern of the boat and left in the water while sampling was done. Movement of the boat produced trolling action in the sunken fly and resulted in catching fishes; in each case they were rainbows. This "fishing," incidentally to other activities, was over deeper water than normal fly fishing. Likewise, it was apparent that cutthroats utilized more of the surface and shoal area than did the rainbows. All rainbows were caught from two deep holes, whereas cutthroats were recovered chiefly from shoal areas. Fly fishing did not produce as high return per angling effort as would have been the case had bait and spinner fishing also been used.

A survival of 71.3 per cent for cutthroat trout is unusually high, when compared with other recorded survival records. When consideration is given to the fact that a single age class was represented in the population during the period, and conditions of food and temperature were satisfactory, this survival rate does not then seem unusual. It is evident that fishes of this size, having a mean length of 8.64 centimeters (3.3 inches) are able to forage actively immediately after planting. Stomach analyses indicated that there was no interpredation. The utility of survival data under such conditions is of importance in practical fish management as indicating the advantage of eliminating older age classes before restocking ponds. The establishment and maintenance of populations of one age class is especially applicable when private ponds and small lakes are to be managed by an individual or private group which can control and manipulate the harvest with this point in mind. In areas where control of the population is not possible, a knowledge of the prevailing age classes and frequency of occurrence is desirable to determine the restocking policy for that area. The condition factor of each fish was computed from the formula $CF = W\ 100/L^3$, where W is weight in grams and L represents standard length in centimeters. The mean CF for the 214 cutthroats taken was 1.30, whereas the 251 rainbows possessed a mean CF of 1.46. This is a species difference rather than an environmental effect. The value of an analysis of the condition of these fishes by use of CF data is doubtful. In general, the condition curves of both species were parallel in trend. High factors were obtained in the final sample because lowering of the water level concentrated the food organisms in a small area and the stomachs of fishes taken in the last sample were full. The mean CF throughout the period most nearly approximated that of mid-summer.

SUMMARY

Three separate plantings of trout were made in Cronemiller Pond, an artificial impoundment of 2.75 acres in western Oregon. Rainbow trout and Loch Leven trout were used in the first two plants, but because of possible escapement and losses from other causes, no reliable survival data were available. The percentage gains in weight and

length are shown for the fish recovered.

The third planting, consisted of 300 hatchery cutthroats and an unknown number of wild rainbow fry and was checked carefully throughout a period of 14.5 months. Survival, and weight and length increments for the cutthroats and weight and length increments for the rainbows are given.

Survival of 71.3 per cent is considered high as compared to other records. The chief factor for this survival rate is the presence of a single age class which eliminated a possible loss through interpredation.

Condition factors for all specimens of the last plant were computed, being 1.30 for cutthroats and 1.46 for rainbows. The higher factor for the latter is considered a result of racial characteristics.

The production in pounds, based upon the gain in weight of each fish from liberation to removal was 128.1 pounds or 46.5 pounds per surface acre of water.

The importance of knowledge of age classes present at any given time is pointed out in relation to management of similar water areas.

Observation of trout production and survival in this artificial pond for three and one-half years has demonstrated the feasibility of raising these fish without artificial feeding for recreation and food. A survival of 71.3 per cent from fish raised to 3.3 inches in a hatchery before liberation is possible provided fish of one age class are present and no predation or escape is permitted. Impoundments of water from small streams of maintained flow throughout the year hold possibilities for development of fish production units on many farms.

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INSTRUCTIONS FOR THE INCUBATION OF EIDER DUCK EGGS[1]

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The Aim of Incubation

Despite the great value of eider-down, the obtaining of this product was formerly accompanied by inexcusable waste. The eider ducks (*Somateria mollissima* L.) were killed for meat and the eggs eaten. Instead of raising the ducks for down, the breed was rapidly being exterminated. Consequently our problem has been to organize the breeding of these birds on a large scale. As a step in this direction we introduced the method of incubating their eggs. After the ducks had completed their laying we collected all the eggs on the given territory. By a second search over the same territory about two weeks later, we discovered many additional eggs, showing that when the eggs are taken away, the ducks lay again. This has been substantiated by the researches of M. M. Sleptsow, who dissected a number of females after the second collection of eggs and found as many as 14 burst follicles (a normal clutch does not exceed 7 eggs). We found that proper incubation of eider duck eggs, followed by the rearing of the incubated ducklings by female eiders, or even artificial rearing, makes it possible to increase the stock considerably from year to year.

These instructions are based on research work carried on by the writer during the summers of 1939 and 1940 in the Seven Island Reservation in the Barents Sea.

Gathering the Eggs

Eggs should be gathered, if possible, when freshly laid, though eggs which have been incubated for not more than 7 days may also be used. The correct time is determined by observing the behavior of the female ducks in any given region. The gathering should begin before they complete their layings. For more accurate results the stage of development of the egg may be determined with a portable ovoscope.

When the eggs do not have to be carried a long distance, they may be placed in plywood boxes (25 by 25 cm. and 10 cm. high). The bottom, walls and cover should be padded, preferably with felt. The boxes are divided by cardboard compartments to keep the eggs separate. The eggs should be placed with the larger ends upward, and the greatest care should be taken in carrying them to prevent jarring. When they must be carried long distances, precaution should be taken also to ensure them against cooling. For the transportation of eggs the writer devised a box of the following construction (Fig. 1).

[1] Miss Rolnik sent her manuscript to me requesting that it be published in this country as she was entering the Red Army as an interpreter. The work she has accomplished in finding proper conditions for artificial incubation of eider duck eggs should certainly not be lost. It has possibilities for management of the eider duck and also has possible applications for increasing the annual productivity of other species of waterfowl.—S. C. Kendeigh.

The upper section is composed of four plywood drawers containing cardboard compartments for the eggs. The lower section comprises two firmly covered metal drawers for hot water, which must be renewed upon cooling.

All eggs are numbered and registered on special record sheets (Form 1).

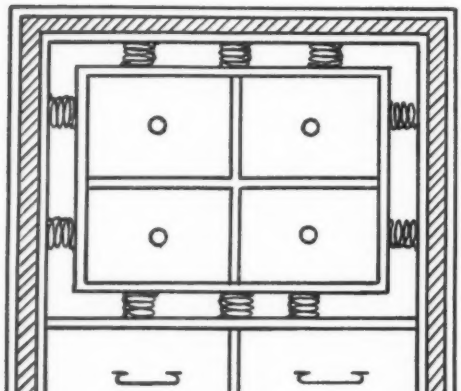

Fig. 1. Section through spring-cushioned and insulated case for transporting eggs (See text).

Prior to placing in the incubator, eggs that have received some incubation should be kept a minimum length of time; even those that have not been incubated should not be kept more than five days.

PLACING IN THE INCUBATOR

1. It is first necessary to examine each egg with an ovoscope to determine its degree of freshness and the approximate stage of development of the embryo. The results are noted on the record sheets (Form 2). As one gains experience, the stage of development may be determined quite precisely within a day or two:

a. Yolk motile, air chamber small, embryo spot bright—not incubated.

b. Yolk only slightly motile, embryo spot dark—incubated 1 to 2 days.

c. Developing embryo visible; blood vessels only very slightly developed; in a weak light $\frac{1}{3}$ of the egg appears dark—incubated 3 to 4 days.

d. Network of blood vessels embracing half of the egg in the region surrounding the embryo; in a weak light $\frac{1}{2}$ of the egg appears dark—incubated 5 to 6 days.

e. Two-thirds of egg appears dark—incubated about 7 days.

Eggs with embryos as far advanced as 7 to 8 days should not be gathered. Their transport considerably lowers the hatchability. Moreover, the chief aim of incubation may not be realized, since the eider duck after having set for 7 to 8 days may lose her ability to lay a second clutch.

2. The eggs are then divided into two groups:

a. Those not incubated or with embryos not over 2 days old; and

b. Eggs incubated more than 2 days. If possible, these two groups are placed in different incubators or in different sections of an incubator.

3. Next the eggs are weighed with an exactitude of 0.1–0.5 gram. The data of this and subsequent weighings are duly recorded (Form 3).

4. Near the large end of each egg is written clearly (with an ordinary, not indelible, pencil) the number given it at the time of gathering, and on both sides of the small diameter the signs + and 0 to facilitate turning the eggs exactly 180°.

5. Eggs soiled by droppings are quickly washed with cheese-cloth dipped in warm water (28°–30°C.) and placed while still moist in the incubator. At the same time the unsoiled eggs are likewise placed in the incubator.

6. In the record book and on the record tab, with which each incubator is provided (Form 4), the time (month, day, and hour) of placing the eggs in the incubator is noted.

INCUBATION REGIME

1. The incubator house should be kept clean and orderly. Prior to the beginning of the incubation season the incubators should be disinfected, preferably with alcohol. Before handling any eggs the operator's hands should be carefully washed.

2. The temperature in the incubator house should be kept at 21°–23°C., the humidity at 65 to 75 per cent. This should be adhered to strictly, since changes will reflect seriously on the results of incubation. Data on the temperature and humidity of the incubator house are recorded every four hours (Form 5).

3A. TEMPERATURE

a. For measuring the temperature and humidity two thermometers are suspended in each incubator at a distance of 15 to 20 cm. from the door. The mercury bulbs of these should be just above the eggs but not touching them. The mercury bulb of one is wrapped in a small piece of thin material which should be clean and kept moist with distilled or rain water. A third thermometer is suspended in each incubator so that its bulb is near the bottom of the tray to measure the temperature at the lower level of the eggs. Two or three days before placing eggs in the incubator the incubator lamp should be lighted and the required average daily temperature for the upper level of the eggs (see *c* below) should be attained by aid of the regulator.

b. During natural incubation in the eider duck's nest, the temperature often changes. During the course of prolonged natural selection these fluctuations became optimal for the development of the embryos in the eggs. Consequently, in artificial incubation it is absolutely necessary that the temperature should fluctuate to attain good results, changing every half hour or even oftener. This change is achieved by opening the incubator door for 30 seconds, when the temperature is recorded and when the eggs are turned.

c. The temperature at the upper level of the eggs should range from 36° to 39.5°C., the average daily temperature being kept at 38.0° to 38.5°C. during the entire period except the last 2 or 3 days of incubation. To attain the indicated mean daily temperature, that at the upper level should, for the most part, be kept at 38.5° to 39°C. During the last days of incubation (22nd to the 26th day) it should be lowered to 37.5°C. by longer and more frequent periods of cooling. Any increase in the temperature above the normal should be avoided, because an increase of even 1°C. may have an exceedingly deleterious effect on the further development of the embryo, and at 42°C. or over all of the embryos may perish. If it is noted that the temperature in the incubator exceeds 40°C. the tray with eggs should be quickly removed and allowed to cool for 5 to 10 minutes. A

temperature as low as 32°–33°C. for a short period is not dangerous.

d. The temperature at the lower level of the eggs depends in large measure on that of the incubator room and on the stage of development of the eggs. A gradual increase in the mean daily temperature at the lower level from 33° or 34°C. at the beginning to 35° or 36°C. at the end of incubation has been found to be normal. In case of a higher temperature at the lower level, the temperature at the upper level should be lowered. For example, if the mean daily temperature at the lower level is 35°C. at the beginning of incubation, the temperature at the upper level should be lowered to 38°C.

3B. HUMIDITY

a. The humidity in the incubator should range between 55 and 65 per cent. From the 5th to 15th day it should be nearer to 55 or even 50 per cent, but toward the end of the incubation period should be increased to 60 or even 70 per cent.

b. To increase the humidity, we combine two methods: wet sand and moistened cloth are placed on the pans, and moistened pieces of cheese-cloth may be hung near the trays and the eggs may be sprinkled with water heated to 37°–39°C. If the humidity exceeds that required, the amount of wet sand or cloth is decreased or the pans are removed from the incubator for a short time.

4. Every two hours the eggs must be turned 180° along their small diameter, turning them from the side with the sign + to that with the sign 0, and vice versa.

5. The eggs are cooled twice a day; at the beginning of incubation 5 minutes each time, and toward the end of incubation as long as 10 minutes. During the cooling, the tray with eggs is removed from the incubator and the incubator door closed.

6. For cooling the eggs and to increase the humidity, if too low, it is advisable to sprinkle the eggs once or twice a day.

7. The incubators should be under constant observation day and night. The temperature, humidity, and other data concerning regime within the incubators should be recorded once every hour in the record books of each incubator (Form 6).

8. To systematize work in the incubator house, the plan of work should be hung on the wall for ready reference (Form 7).

9. Our experiments on the incubation of eider-duck eggs were made in small sectional incubators, "Prairie" and "Syphers"; for other types of incubators it may be necessary to make some changes in the regime.

HATCHING

1. During hatching the ducklings should not be assisted in emerging, but left to get out of the shells by themselves. Aid should be given only in case, all the embryos being of like age, the ducklings hatch from all of a given lot except three or four, in which the shell is pecked or not, a chirping has been heard for several days. If the shell has been pecked a little, one should carefully remove small pieces of the shell with pincers to enlarge the hole. As soon as there is any sign of blood, no more shell should be removed, and on the place where the blood appeared

there should be placed a small piece of clean gauze moistened in warm water and the egg put back in the incubator. After a short interval one should continue to remove pieces of shell. When the opening has become large enough, the head of the duckling should be carefully lifted from under the right wing and the egg replaced in the incubator. The duckling should emerge from the egg by itself. Loss of blood as a result of the artificial freeing of a duckling from an egg is very harmful, frequently leading to great weakness or even death. Aid at hatching is permissible therefore only in extreme cases and should be executed with exceptional care. Moreover, the operation should be so performed that no infection results.

If the shell has not been pecked at all, the egg should be candled and the beak and the air chamber located. At a point near the beak the shell should be carefully broken in, and then the operation should be completed as in eggs whose shells have already been pecked.

2. After hatching the ducklings are left alone in the incubator for two hours and removed for a day or two in the drying compartment of the incubator. Each duckling is banded at this time.

3. As soon as the ducklings are dry, they should be weighed.

4. When the hatching has been completed, the unhatched eggs should be removed from the incubator. Failure to hatch is usually due to the incorrect position of the duckling in the egg or to its inability to draw in the yolk-sac. Normally, the duckling lies lengthwise in the egg with its tail in the small end, its head (under the right wing) and beak near the air chamber and its feet pressed up next to its abdomen.

BIOLOGICAL CONTROL OF INCUBATION

1. CANDLING

a. The eggs are usually candled on the 6th, 12th and 18th day of incubation; that on the 12th day may be omitted.

b. When examining an egg with the ovoscope, one should note the movement of the embryo, the pulsation of the blood vessels, and the degree of development of the embryo. This is not difficult, since many are examined at the same time. These data are recorded on Form 2.

c. On the 6th day, after candling, all infertile eggs in which no embryonic development has commenced, and all eggs with dead embryos (usually surrounded by a blood ring) are discarded. On the 12th and 18th day again all eggs with dead embryos are discarded. That an embryo is dead is established by absence of any movement of the embryo or of pulsation of the blood vessels, by the outline of the embryo being blurred and indefinite, and, lastly, in some cases by the characteristic stench of a rotten egg.

d. None of the eggs discarded after candling should be replaced in the incubator, since this may lead to the loss of a large number of eggs. All discarded eggs should be opened immediately, and the following data recorded (Form 8): age of embryo, size, state of internal organs, presence or absence of a blood ring, adherence of embryo to the shell, maceration, etc. Later, by the aid of these pathologico-anatomical data it may be possible to determine the defects in the incubation regime.

e. If on the 6th day candling reveals many eggs having blood rings, this

shows that the regime during the first days of incubation was incorrect. Usually it is a sign of prolonged over-heating.

2. WEIGHING

a. The eggs are weighed on the 5th, 10th, 15th and 20th day of incubation (Form 3).

b. Each egg is weighed separately to within 0.1–0.5 gr., and then the loss of weight (by drying) for each egg and for the entire lot is determined.

c. The average loss of weight of each lot of eggs amounts to: for the first 5 days, 1.4–2.4%; for 10 days 3.4–4.7%; for 15 days 5.7–7.8%; for 20 days, 8.4–11.0%. The normal weight of a newly hatched duckling is 67–69 per cent of the original weight of the egg.

d. If the loss of weight is greater than above indicated, the humidity should be increased and the temperature slightly lowered; if the contrary is the case, the humidity should be decreased. If the newly hatched ducklings weigh more than the norm, this is usually due to insufficient drying out of the eggs or to insufficient utilization of the yolk; underweight ducklings result from excessive drying of the eggs and incomplete utilization of the white.

e. The candling and weighing of the eggs should be so organized that the eggs are not cooled too much and are not shaken.

3. CHARACTERIZATION OF HATCHING

The duration of incubation, the length of time for a duckling to emerge from the shell, the duration of the hatching period, the condition of the allantoic vessels remaining on the shell after the emergence of the duckling from the egg, the protrusion or non-protrusion of the yolk sac and the external appearance of the ducklings are directly connected with one or another result of the hatching and serve as indices of the correctness of the regime followed during the given incubation season. All the data enumerated above should be recorded (Form 8).

a. The normal duration of incubation is 24 to 25 days. Deviations are accompanied by a lowered hatching percentage and indicate that the incubation regime is not correct. High humidity and high temperature accelerate development and shorten the incubation; low humidity and low temperature produce an opposite effect.

b. The duration of hatching—from the moment of the first peck to the moment of the emergence of the duckling from the egg—is correlated with the rate at which the yolk sac is drawn into the body. Normally it takes a duckling about 30 hours to hatch, by which time its yolk sac usually no longer protrudes; if hatching takes 25, 20 or less hours, the yolk sac may still be protruding. The latter indicates prolonged overheating. A duckling with a protruding yolk sac is comparatively weak, which may affect its further development.

c. The duration of the hatching period of each lot of eggs is measured by the time elapsing from the moment of emergence of the first duckling to the moment of emergence of the last. The shorter this hatching period the better. In any case it should not exceed 48 hours. A prolonged hatching period is due to the temperature being too low or too high during incubation. If it has

been too high, the hatching commences earlier, if too low, later than when incubation has taken place under conditions of normal temperature. Prolonged hatching always gives rise to poor results.

d. After the ducklings have hatched the shells are divided, according to the state of the allantoic vessels, into three groups:

(1) Allantoic vessels entirely colorless or a few vessels filled with blood; the allantoic sheet adhering to the shell film cream-colored;

(2) Allantois light brown in color; a few small hemorrhages;

(3) Allantois dark brown in color; comparatively large hemorrhages.

If most of the shells belong to the first group, this indicates that the incubation regime has been normal, and the results of the hatch are good. If the shells are mostly of the second group, this shows that the temperature during incubation was too low, and the hatch is only about 50 per cent successful.

e. Ducklings well covered with down but with weak legs spread wide apart so they walk jerkily result from insufficiently high temperature during incubation. When the temperature has been too high, the ducklings are less well covered with down, which is moist and sticky, and the ducklings move very little, become cold, and cluster together.

f. Hence, by the aid of biological control data, it is possible to regulate the incubation regime during the course of the work in any given season and for the succeeding season, and also to modify the regime for work with incubators of other types or manufacturers.

BROODING AND REARING OF DUCKLINGS

1. After 24 hours in the drying compartment the ducklings should be placed in a brooder or given to female eider ducks already caring for broods of ducklings. In the latter case, the ducklings are placed in egg-crates (without cardboard partitions) and transported to some place where there are eider ducks with broods. Ordinarily, both on lakes and seas, the female eider ducks, having hatched their young, keep together, 3 to 5 ducks looking after a brood of 9 to 17 ducklings.

When the ducklings are placed in the waters of a lake, they should be so distributed that each female duck will have, together with her own young, 7 to 9 ducklings. Having gently placed the ducklings in the water, one should quickly go to the place where the female ducks are and drive them towards the incubator ducklings. Eider ducks willingly accept incubator ducklings in their broods; after a few minutes it is difficult to distinguish the incubator ducklings from those hatched naturally.

When the ducklings are to be placed in the sea, one should row out to the broods, gently place the incubator ducklings in the water and row away a short distance.

On the way from their nests to the lake or sea the ducks often lose their ducklings and are unable to defend them from birds or beasts of prey. Consequently, incubator ducklings should not be given to a duck still sitting on her nest and brooding her ducklings.

2. The best methods of artificially rearing the ducklings have not yet been fully elaborated. We can only outline

the chief procedure in the care of ducklings during the first 2 or 3 weeks. The temperature in the brooder should be kept at about 28°C. during the first few days and lowered to about 20°C. by the end of the second week. On warm, sunny days ducklings from the age of 2 to 4 days may be let out to run. During the first week they should not be let out for more than an hour or two, but by the end of the second week they may be let out for the entire day and kept in the brooder only during the night or in case of rain or fog.

The ducklings should be fed 5 or 6 times a day. The mash should include: finely chopped egg, moistened bread crumbs, millet mush. The ducklings particularly relish small crabs. Cases have been reported of the artificial rearing of eider ducklings to maturity. This indicates that it may be possible to domesticate the eider duck.

FORMS

[To save space, the titles and column headings of the forms used by Miss Rolnik are condensed here as lists.—*Editor.*]

Form 1. Data on Gathering of Eggs (month, day, hour, and place); nest no.; amount of down; number of eggs; egg nos.; number of days eggs have been incubated; remarks.

Form 2. Data on Candling of Eggs. Incubator; egg nos.; month and day of gathering eggs; date placed in incubator; candling (prior to placing in incubator; on 6th day of incubation; on 12th day; on 18th day).

Form 3. Incubator. Egg nos.; date placed in incubator; weight (before incubation; after 5 days [weight; loss in weight in grams and percentage]; after 10, 15 and 20 days similar data); weight of ducklings. *Note:* Weights of eggs should be recorded for each lot to facilitate calculation of percentage weight loss in each.

Form 4. Incubator Record Tab. Name of incubator or section in which placed; numbers of the eggs placed; month, day and hour when placed; weighings (5th, 10th, 15th, 20th day); candling (6th, 12th, 18th days); temperature at upper level (38.5°C.); temperature at lower level (33–34°C. until a given date, 35–36°C. thereafter); humidity (50–60% until given date, 60–70% thereafter); turning of eggs (12 times per day); cooling of eggs, twice a day (5 minutes until given date, 10 minutes thereafter); sprinkling of eggs, if necessary, indicating how many times per day.

Form 5. Temperature and Humidity in Incubator House. Month and day; hour; temperature; dry bulb, wet bulb; humidity (in %).

Form 6. Temperature and Humidity in Incubator No. ____. Month and day; hour; temperature (at lower level; at upper level by dry bulb, by wet bulb); humidity (in %); turning; cooling; sprinkling.

Form 7. Plan of Work in Incubator House. Month ____; date; incubator ____; operations: sprinkling, candling, etc.; remarks.

Form 8. Data on Opening of Unhatched Eggs. Serial no.; age; position; white; yolk; allantois; general appearance; skin and feathering; head and brain; neck and crop; limbs; stomach and intestines; liver; heart; kidneys; remarks.

Form 9. Data on Hatching. Incubator; egg nos.; stage of embryo before placing egg in incubator; month, day, hour placed; month, day, hour of hatching; condition in allantoic vessels in shell after hatching; protrusion of navel [yolk sac]; description of duckling; band no.

MIGRATION AND FATE OF TRANSPORTED JUVENILE WATERFOWL

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The study of the homing instinct of migratory birds, that mysterious and still unexplained ability which unerringly guides avian travelers, sometimes through darkness, fog, and storm, is intriguing and also is important in practical avian management. The ability and inclination of birds to travel ancestral flyways and to return to the same nesting or wintering ground has long been known and in recent times has been amply demonstrated through records from banded birds (Lincoln, 1935). The regularity of such movements, particularly during spring migrations, has demonstrated time and again that individuals of seemingly aimless flocks may, in fact, be creatures of precision with respect to time, place, or direction. Once established, only a most impelling cause will alter for the individual its use of a migratory route, a nesting area, or a wintering ground.

The attachment of birds to their nesting grounds is pronounced, and is common to most if not all species. This is attested by many experiments; some conspicuous examples are the observations by Baldwin and Bowen (1928) on the return of transported house wrens, the researches of Lyon (1935) and of Gillespie (1930) with cowbirds, studies by Kluiver (1935) and Rüppell (1936, 1937, 1938) of starlings, martins, and swallows, and of Kratzig and Schuz (1936) with starlings, of Lack and Lockley (1938) with a number of maritime species, and of Watson and Lashley (1915) with sooty and noddy terns. Much of this experimental work involved the transport of adult birds just before or during the nesting season when the homing instinct was most pronounced.

Some of these same workers, as well as others, have also transported adult birds from their regular wintering haunts to distant points and observed their return to accustomed habitats or migration routes. Of significance in connection with the experiments here reported has been the work of McIlhenny (1934) with adult waterfowl trapped in Louisiana at the southern end of the Mississippi flyway and released at points of the Pacific and Atlantic flyways. A large proportion of those recovered were retaken in the Mississippi flyway giving indication of the strong attachment these waterfowl had for their ancestral migratory route. In this case, however, the birds involved had made at least one flight from their nesting ground.

From the standpoint of Federal refuge management, the question arises, "how successful will be the restocking of depleted areas if non-pinioned specimens possess such an urge to return to points whence they came?" Will it ever be possible to repopulate depleted areas with physically normal adult stock obtained in other flyways? The available evidence indicates that it will not be and the birds either will have to be pinioned or kept in captivity long enough

to produce young that will look upon the new area as their home. Liberated, pinioned birds are under a handicap and may even become a problem in management on northern refuges where winter feeding would be called for.

There remains, however, the possibility of accomplishing restocking by transporting juveniles which may not have acquired an affinity for their natal homes or flyways. Therein lies the theme of this paper, involving considerations not only of wildfowl management but also those associated with the study of the homing and migratory instincts of birds. There is little previous experimental work in the transporting of juvenile birds and the recording of their subsequent migrations, but mention may be made of some that have application.

Hornberger (1934) reported on numbers of storks taken from their nests in East Prussia and raised in Rossiten. Of these 73 were released at Rossiten, 20 at Frankfurt am Main, and 144 at Essen near the western border of Germany; each set of birds was distinctly colored to aid in making sight records of returns. Nearly all of the birds went south or southeast, and this was considered to be evidence of the inheritance of an ancestral migration direction, followed even in a locality where the native birds migrated in another direction. The distances these storks were transported were not as great as those involved in our shipments of American waterfowl which may have accounted for the birds reacting differently from those reported on here.

Rüppell (1938), on the other hand, took young starlings from nests, reared and retained them in captivity until the following spring, when some began to carry nest material and lay eggs. At that time 15 were marked with colored bands and transported 115 kilometers to the south. Despite a diligent search in the area of their birth none was again reported there indicating, it would seem, that no great attraction had been developed in these young birds for the place of their birth and early juvenile life.

Schuz (1931) in his review of experiments dealing with the sense of direction in birds recites the case of a swift taken from its nest in Braunschweiz to be reared and liberated in Berlin, where it returned the following spring. This, it was felt, gave indication as to what part of the "home complex" and early life of the bird was most effective in influencing the bird's homing instinct.

An experiment similar to one of those here reported (Table 1, Lot 4) was performed by Karl Fazer (Valikangas, 1933) in cooperation with the Zoological Museum of the University of Helsingfors (Helsinki). Eggs of English mallards (considered non-migratory) were sent in the spring of 1931 to Taubild between the Gulf of Finland and Lake Ladoga. Of these, 86 hatched and grew up in freedom with wild ducks although regular feeding kept them partially tame. Later in the year 62 were banded and all left their rearing ground in the middle of November. Returns from these banded birds and observations made on others that reappeared near Lake Ladoga during the following spring indicated that these English mallards behaved like resident birds, and all recoveries fell within the regular migration route of Finnish mallards.

Thus, in these European experiments,

Table 1.—RECORDS OF TRANSPORTED DUCKLINGS AND DUCK EGGS AND THEIR FATE.

Lot no.	Birds released	Transported from	Point of release and date	Time and place of recovery and distance traveled
1	48 pintails	Delta, Man. (Mississippi flyway)	Blackwater Refuge, Md. (Atlantic flyway) 7/4/38	3 returns: 2 in the Atlantic flyway and 1 in the Mississippi flyway no. 38-701569, 11/18/38, Brandywine, Md., traveled 40 mi. NW. no. 38-701540, 11/16/38, Havre de Grace, Md., traveled 70 mi. N. no. 38-701536, 10/8/39, Fond du Lac Co., Wis., traveled 780 mi. NW.
2	49 pintails	Delta, Man. (Mississippi flyway)	Malheur Refuge, Ore. (Pacific flyway) 7/5/38	no returns
3	6 mallards 18 pintails	Lower Souris Refuge, N.D. (Mississippi flyway)	Malheur Refuge, Ore. (Pacific flyway) 7/18/38	4 retrapped and 1 return in the Pacific flyway pintail, no. 36-670636, 11/19/39, Bixler, Calif., traveled 400 mi. S.
4[1]	8 gadwalls 2 mallards 1 pintail 1 redhead 1 shoveler	Malheur Refuge, Ore. (Pacific flyway)	Delta, Man. (Mississippi flyway) 8/8/38	one repeat and 1 return in the Mississippi flyway mallard no. 38-716350, 10/11/38, St. Laurent, Man., traveled 25 mi. E.
5	30 blue-winged teal 1 baldpate	Lower Souris Refuge, N.D. (Mississippi flyway)	Blackwater Refuge, Md. (Atlantic flyway) 8/8/38	no returns
6	28 blue-winged teal	Lower Souris Refuge, N.D. (Mississippi flyway)	Malheur Refuge, Ore. (Pacific flyway) 8/8/38	no returns
7	7 cinnamon teal 4 pintails 3 mallards 6 gadwalls	Malheur Refuge, Ore. (Pacific flyway)	Lower Souris Refuge, N.D. (Mississippi flyway) 8/11/38	3 returns, all from the Mississipi flyway mallard no. 38-733813, 10/15/38, Weaver, Minn., traveled 500 mi. ESE. gadwall no. 38-617512, 10/3/38, Tamarac Lake. Minn., traveled 370 mi. SE. gadwall no. 38-617513, 11/11/38, Heron Lake, Minn., traveled 460 mi. SE.

[1] Eggs from the Malheur Refuge shipped to hatchery at Delta, Manitoba, for incubation, and young released there when about 6½ weeks old.

transported young storks appeared to revert to their ancestral migration route; the starlings and swift showed no such tendency; and transported eggs of mallards produced young which behaved like native birds among which they grew up.

The experiments here reported comprise two groups, one dealing with the fate of transported goslings and the other with ducklings. The former were in connection with an experimental restocking program at Federal refuges, and the latter largely on Federal ref-

uges to learn whether attachment to a flyway is a characteristic possessed by young ducks which have never made a migratory flight. The goslings were shipped in 1939, and all the ducklings were transported in 1938.

TRANSPORTED CANADA GEESE

Each year since 1937 it has been a practice at the Bear River Migratory Bird Refuge in Utah to band a significant percentage of the young Canada geese produced on that breeding ground. Difficulty was experienced during the first year in perfecting a trapping method which would permit wholesale banding, but in 1938 the difficulty was overcome so that in 1939 experiments with transporting young stock to other areas could be undertaken. In July, 1939, 399 adult geese and 812 goslings were trapped and banded, and 133 were shipped to other national wildlife refuges in north-central United States where Canada geese formerly bred in abundance and where it was desirable to restore the breeding populations, as follows:

Mud Lake, Holt, Minn.—34 juveniles
Sand Lake, Columbia, S. D.—37 juveniles
Lower Souris, Upham, N. D.—22 juveniles
1 adult
Necedah, Necedah, Wis.—38 juveniles, 1 adult

The fate of each shipment is considered individually because the interpretation of results is influenced by the handling and care of the transported stock which, of necessity, was variable at each refuge. The results are still incomplete, but indicate what may be expected within the next few years.

Mud Lake National Wildlife Refuge, Holt, Minn. The 34 juveniles were all wing-clipped (not pinioned) on arrival in July, 1939. All but seven (except two killed by mink during the winter) became full-winged during the summer of 1940, and 25 were able to migrate in the fall. Four returns (16%) were received, 3 from Mentor, Minn., November 23, 1940, and 1 from Erskine, Minn., November 24, 1940. All were apparently within 10 miles of each other and about 45 miles from Mud Lake. The available data indicated that the birds adapted themselves to new conditions and had no inclination to return to their original breeding area in Utah.

Sand Lake National Wildlife Refuge, Columbia, S. D. The 37 juveniles all were permitted to retain their flight feathers. There has been only one return from the area, a juvenile found dead from unknown cause on the refuge, November 20, 1940. The birds made themselves at home on the area which seemingly provides all the necessary habitat requirements for a successful transplanting as Watson Beed, Manager of the Refuge (letter, October 2, 1941) stated: "Last year none of the birds nested but this year the geese scattered over Mud and Sand Lake and 50 goslings were counted. There was no migration either in 1939 or 1940 and about 20 (other) wild birds spent the winter here with them." The fact that some of the young birds of 1939 produced goslings of their own in 1941 was wholly unexpected and most certainly is indicative of their satisfaction with the new environment. Present indications are that return of these birds to the Utah flyway is unlikely.

Lower Souris National Wildlife Refuge, Upham, N. D. The 23 birds released were the second restocking on the area. In 1937, 22 pinioned geese

from Malheur, Ore., had been introduced and produced about 18 goslings each year to 1940. In 1941 Merrill C. Hammond, the resident biologist, estimated that 30 to 40 goslings were produced. Of these some later migrated and 11 were shot at locations in Colorado, North Dakota, Nebraska, and New Mexico.

Ten of the birds transported from the Bear River Refuge were wing-clipped prior to release, but the remainder were full-winged at all times. Only two returns have been recorded at significant distances. One was taken November 28, 1940, at Crook, Colo., a locality at which birds from the first restocking were also taken by hunters. The other return of a Utah transplant was from Moose Lake, Manitoba, on October 5, 1940. Neither locality is within the flyway of Utah birds. The data are meager but show that the transplanted geese remained within their adopted flyway with no indication of again joining the Oregon and Utah flocks.

Necedah National Wildlife Refuge, Necedah, Wis. The 39 geese were wing-clipped before release and attempts were made to do so each year to maintain a captive flock. Ten birds, however, escaped and became full-winged. Robley W. Hunt, refuge manager, reported (Sept. 29, 1941) that "four of the fliers are observed almost daily on the Rynearson pools, while six of the fliers are still remaining with the clipped birds. If approached too close, however, they will fly out of the pen and return when the coast is clear." The birds have not nested, but the fact that full winged birds make no effort to leave indicates they have acclimated themselves to the new sets of conditions.

The data from transplanting of juvenile Canada geese from Bear River to areas outside of their normal flyway indicate that they show no tendency to return to the area from which they came. The young, even though not wing-clipped, readily adapted themselves to their new habitats. The speed of adjustment probably varies with how well their requirements are provided for in the new area; breeding possibly occurs during the second year in favorable localities. The restocking of refuge areas with juvenile Canada geese thus can be considered a worthy management measure to follow wherever over-shooting and habitat destruction have been remedied.

TRANSPORTED DUCKLINGS

In the experiments with ducklings, efforts were made to learn whether these young birds would return to their ancestral flyways; a program of restocking was not directly involved. The points of origin and destination of these shipments are shown in Table 1, along with the records of returns of the banded birds.

The Delta Duck Hatchery at Delta, Manitoba, served as a point of origin and release of transported birds. Through facilities generously contributed by James F. Bell, owner, and Edward Ward, manager, eggs sent there were incubated and the young reared to an age permitting their release. Birds hatched from locally collected eggs also were contributed by the Delta Duck Hatchery for shipment to the Blackwater and Malheur refuges. At the three wildlife refuges assistance was rendered by the respective managers and biologists, C. J. Henry and M. C. Hammond

at the Lower Souris Refuge, Clarence A. Sooter and George W. Benson at Malheur Refuge, and David V. Black at the Blackwater Refuge.

A total of 213 ducklings were eventually released. Of these 13 had been transported as eggs and hatched and reared at the point of destination (Table 1, Lot 4). The ducklings varied in age from 4 to 8 weeks. From these 8 "returns" have been recorded; in addition 5 "repeats" were reported at banding stations operated at the Delta (1) and Malheur refuges (4).

Of the 8 returns listed (Table 1) only pintail no. 38–701536 indicates a recovery in a flyway other than that in which the bird was released; it returned to the Mississippi flyway in which it had hatched. It will be noted, however, that *the recovery is in the year following* its release in the Atlantic flyway. What happens in such cases when there is an intervening breeding season and migratory flights is always problematical, since one cannot be certain where the bird passed the interim. Certainly there is no basis for assuming that the bird went directly back to its ancestral flyway; more likely it traveled from a wintering home somewhere in the Atlantic flyway to a northern breeding ground (possibly in central Canada) and then, on its way south, followed the Mississippi flyway.

It would indeed have been fortunate if more records of the latter type were available, since an affinity for an ancestral flyway possibly may be retained by a duck and be exhibited on the first normal flight from a breeding ground. Our limited records reveal merely that ducklings moved from one flyway to another show no inclination to hasten back to their original flyway when they acquire the ability to fly.

If the percentage of returns obtained from these transported ducklings may be taken as an index, the survival rate over natural mortality among such birds is abnormally low. Six of the eight returns were reported in the fall of the year in which they were released and the other two were recorded in the following year (1939). The six returns recorded during the first hunting season following the release of these ducklings represent less than 3 per cent of those released, whereas the return from banded ducks of the year is normally considered to be from 12 to 14 per cent during a similar period of hunting pressure. The fate of transported young geese has been most encouraging to the Federal program of wildfowl rehabilitation, but that of ducklings has been quite the opposite. Even though the scant evidence indicates that survivors may remain in the flyway to which they they were moved, their existence there appears to be precarious.

SUMMARY

The attachment of adult birds for their nesting and wintering grounds and ancestral migration routes has been demonstrated repeatedly. Since this marked homing instinct would tend to nullify programs of waterfowl restocking if adult non-pinioned birds are used, it becomes a matter of consideration in practical wildfowl management.

The possibility that juvenile birds, which had not made a migratory flight, might not possess so pronounced a homing instinct and could therefore be used in restocking programs without the crippling effects of pinioning, served as

the practical incentive in the experiments here reported. There was also the desire to contribute to the limited published information on the movements and homing instinct of transported juvenile birds.

A total of 131 juvenile Canada geese, captured and banded at the Bear River Migratory Bird Refuge in Utah, were shipped to four national wildlife refuges in the Mississippi flyway and released. Returns from these transported birds indicate that their migrations, when made, were similar to those of birds native to these refuges. There was no evidence of an urge to return to the Great Basin whence they came.

A total of 213 ducklings were involved in shipments between points in the Atlantic, Mississippi, and Pacific flyways. These yielded only 8 returns, all but one of which indicated that the birds remained in their newly adopted flyways. The exception was a pintail recovered in its ancestral flyway during the second fall after its release.

In contrast to the generally successful program of restocking with geese, the low percentage of returns from transported ducklings indicates that the procedure as carried out was not desirable from a management standpoint. Possibly birds of the year captured later in the summer after they had gained their full vigor might give better results.

The returns available indicate strongly that both goslings and ducklings, when transported to other flyways, do not have an urge to return to their natal homes or flyways, but adopt the migratory habits of birds among which they grow up.

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VITAMIN A DEFICIENCY IN BOBWHITE QUAIL

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During the summer of 1940, a local breeder brought to the writers several bobwhites (*Colinus virginianus*) about five weeks old that were afflicted with severe ophthalmia, and characterized by emaciation and a ragged, drooping appearance (Pl. 10, *A*, *B*). The breeder stated that only one hatch of quail was so afflicted; all others appeared normal. The same brand of growing mash for gamebirds had been used for all his birds, a popular one from a very reputable firm. The afflicted quail, however, had been fed, from the time of hatching, on a new lot of the mash in which deterioration may have occurred.

The symptoms indicated avitaminosis A with secondary bacterial infection of low virulence. According to Dr. Don Coburn of the Disease Investigations Unit: "None of the bacterial invaders cultured appeared to be of pathological importance. The extent of healing with scar tissue formation prevented complete recovery when the birds were placed on a diet containing ample amounts of vitamin A. Progress of the inflammatory changes was immediately arrested, however, and complete healing of all lesions quickly accomplished."

As this condition in bobwhites had received little or no attention by research workers, two experiments were made with chicks and adolescent stock, to determine the symptoms of vitamin A deficiency.

Test No. 1

Ten bobwhite chicks, 24 hours old, were placed in each of two battery-brooder units, *A* and *B*. They were the offspring of breeding stock that had received laying mash containing approximately 5,000 International units of vitamin A per pound of feed. Both lots of chicks were fed the following mixture (parts by weight):

Ground white corn	36.5
Soybean oil meal	43.0
Dried buttermilk	16.0
Salt mixture	2.0
Ground limestone	1.2
Special steamed bonemeal	0.9
	99.6

The salt mixture comprised common salt, 2,000 parts; anhydrous ferrous sulfate, 11 parts; anhydrous manganous sulfate, 17.0 parts; potassium iodide, 0.2 part; and anhydrous copper sulfate, 0.2 part.

This diet contained approximately 28 per cent of crude protein, 1.12 per cent of calcium, 0.7 per cent of phosphorus, 100 international units of vitamin A per pound of feed, 550 international units of thiamin, 2,200 micrograms of riboflavin, and 1.1 Jukes-Lepkovsky units of pantothenic acid.

For Group *A*, 0.4 per cent of a concentrate of irradiated cholesterol (160 international units per gram of oil) was added to the feed mixture. For Group *B*, 0.4 per cent of a concentrated mixture of vitamin A (5,400 international units per gram) and irradiated cholesterol (160 international units per gram) was added. Thus both diets contained approximately 290 international units of vitamin D per pound of feed. The diet for Group *A* contained approximately 100 international units of vitamin A per pound of feed and that for

Group *B* over 9,800 international units per pound.

GROWTH, MORTALITY, AND FEED CONSUMPTION

The feed consumption and the results in growth and mortality of the birds for the first five weeks are given in Table 1. Standard weights, in grams, for growing bobwhites, based on data from more than 800 chicks reared on balanced diets, are as follows: End of 1st week, 12; 2nd week, 20; 3rd week, 32, 4th week, 47; and 5th week, 64 grams.

Table 1.—LIVE WEIGHTS, MORTALITY, AND FEED CONSUMPTION OF BIRDS.

Weeks from Hatching	*Group*	*Weight of birds (grams)*	*Feed per bird per day (grams)*	*Deaths*
First	A	12	2.1	0
	B	12	2.4	0
Second	A	21	4.4	0
	B	22	3.9	0
Third	A	29	8.5	0
	B	38	5.8	0
Fourth	A	34	7.5	5
	B	57	9.7	0
Fifth	A	48	6.9	2
	B	77	12.3	0

The growth of the birds in Group *A* on the diet low in vitamin A was normal throughout the first two weeks, but during the third week it dropped below normal and considerably below that of Group *B* which was above the standard. During the fourth and fifth weeks the growth of the surviving birds in Group *A* was very poor.

The feed consumption of Group *A* during the second and third weeks was greater than that of Group *B*. The former birds seemed to be very hungry most of the time. Many of them would run to the caretaker when he replenished the supply of feed in their hopper and peck at his fingers—unusual behavior. Both groups had the same type of feed hoppers and both received the same quantity of feed each day, but the birds of Group *A* wasted considerably more feed than those of Group *B*; during the first four weeks this averaged 6.7 grams and 1 gram, respectively, per bird per day. The birds on the diet low in vitamin A seemed to sense the deficiency and searched through the feed as though looking for some missing food material.

There was no mortality in either group during the first three weeks, an interesting fact in the light of the usual high mortality during this period among bobwhites reared in captivity. During the fourth and fifth weeks, however, there was a heavy mortality among those on the deficient diet.

EXTERNAL SYMPTOMS OF VITAMIN A DEFICIENCY

When the birds of Group *A* were eleven days old, three showed ruffled feathering. There was a tendency for the wing primaries to extend at an angle from the body and droop (Pl. 10, *C*), a condition noticed in late-hatched wild turkeys. Three days later all but one exhibited this abnormal feathering. The growth of the feathers on all parts of the body was considerably retarded.

Sixteen days from the start of the experiment, the right eye of one chick became partially closed; the next day both eyes were closed completely and had pus in the corners. The bird was given 2 grams of vitamin-A concentrate (30,000 international units per gram) and

placed on the diet fed to Group *B*. Three days after treatment its eyes were open again and the primary feathers were nearly normal in position.

Between the 21st and the 31st days from the start of the test, all but two of the remaining birds died. Only one showed severe ophthalmia before death. The eyes of the others remained open until death, but appeared to be weak and watery. In one quail, a half hour prior to death, the legs trembled violently and spread apart whenever the bird attempted to stand up.

One of the two remaining birds had watery, swollen eyes. On the 26th day each was given 1 gram of the vitamin A concentrate but was retained on the low vitamin A diet. Two days later the eyes of both birds appeared to be normal. These two birds lived for 45 days. After inflicting severe injuries on each other by beak-picking, they both died on the same day, apparently as a result of hemorrhage and inanition.

Table 2.—POSTMORTEM FINDINGS.

No. of bird	*Age*	
A 790	21 days	All viscera, especially the heart, covered with deposit of urates.
A 792	23 days	Edema of peritoneum and heart; both ureters obstructed with urates.
A 796	23 days	Liver and heart covered with urates; right ureter obstructed and swollen; proventriculus and duodenum inflamed and hemorrhagic; creamy hard patch in roof of mouth.
A 797	25 days	Kidneys covered with urates; hemorrhage of heart and proventriculus.
A 798	26 days	Ureters obstructed with urates; hemorrhage of heart and proventriculus.
A 791	29 days	Ureters obstructed with urates; hemorrhage of proventriculus; lungs congested.
A 795	31 days	Kidneys and heart covered with urates and ureters obstructed; hemorrhage of lungs.

POSTMORTEM APPEARANCE

The lesions in birds on the low vitamin A diet at autopsy are given in Table 2.

Thus visceral gout was present to some degree in all cases and internal hemorrhages were common.

TEST NO. 2

Six 12-week bobwhites that had been reared on a growing mash containing approximately 9,000 international units of vitamin A or its precursor per pound of feed, were placed in each of two battery units. The following mixture was fed to both groups *C* and *D* (parts by weight):

Ground white corn	80.0
Soybean oil meal	17.5
Special steamed bonemeal	1.5
Ground limestone	1.5

Five weeks later, 1 per cent of the salt mixture mentioned in Test No. 1 was added to the mixture. For Group *C*, this mixture was supplemented by 0.5 per cent of a concentrate of irradiated cholesterol (160 international units per gram of oil); for Group *D* it was supplemented with 0.5 per cent of a concentrated mixture of vitamin A (5,400 international units per gram) and irradiated cholesterol (160 international units per gram). This test was con-

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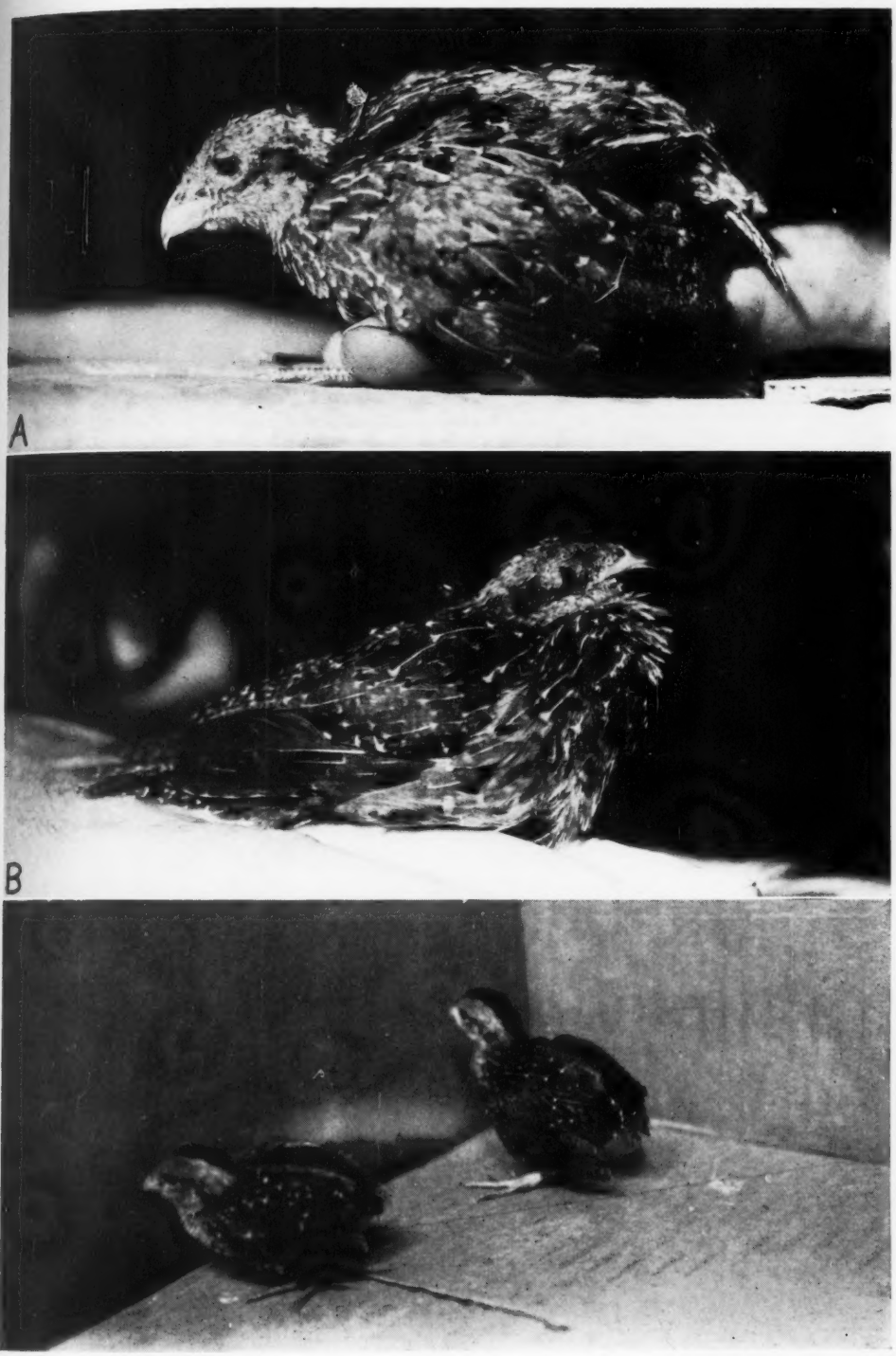

Vitamin A deficiency in bobwhite quail. *A*. Conjunctivitis and ruffled feathers; age 5 weeks. *B*. Severe ophthalmia with eyelid thickened by scar tissue; age 5 weeks. *C*. Feathers ruffled; primaries of wing stand out and droop; age 2 weeks.

ducted over a period of ten weeks, December 9 to February 17.

The differences in the live weights of the two groups during the test and at the close were not significant. Both groups gained weight and assumed normal feathering and both exhibited outbreaks of feather picking prior to the addition of the salt mixture but not afterwards.

Feed consumption per bird during the first six weeks was slightly higher for Group *C* than Group *D*, whereas the reverse was true from the seventh week on; the differences however, were not significant.

Two deaths occurred on the low vitamin A diet, one at 42 days and the other 44 days from the start of the experiment. Autopsy revealed severe visceral gout in both cases. An intestinal tumor was present in one.

At the end of the experiment, the remaining four birds in Group *C* were sacrificed for examination. The viscera in all appeared to be normal.

No deaths occurred in Group *D;* one bird was autopsied and its viscera were found to be normal.

SUMMARY AND CONCLUSION

Two experiments were conducted to determine the symptoms of avitaminosis A in growing and adolescent bobwhites. Chicks from parents that have received a diet rich in vitamin A may have enough stored to carry them a week or ten days on a growing diet deficient in vitamin A before symptoms of deficiency occur. The first sign is ruffled feathering, with the wing primaries standing out from the body and drooping. Ophthalmia in one or both eyes occurs and may close the eyes completely, but this condition is not severe in all cases and may not even be noticeable. Birds show poor growth, loss of appetite, and weakness before death. Under the conditions of the experiments discussed herein, death may occur in the fourth or fifth week, and mortality is high.

Postmortem examination may reveal visceral gout with thick deposits of urates on the kidneys, in the ureters, on the heart, in the proventriculus, and occasionally covering all the viscera. There may also be hemorrhage of the heart and other organs.

Adolescent quail reared on a diet rich in vitamin A may be able to live through the winter on a maintenance diet low in this vitamin without showing symptoms of avitaminosis, but some individuals whose storage of vitamin A in the liver is not as great as that of others may succumb to visceral gout.

A growing mash for quail which contains sufficient vitamin A when fresh may, after a period of storage, lose enough of the vitamin to cause the characteristic symptoms of avitaminosis A to appear.

INTERNAL PARASITES OF THE RED FOX IN IOWA[1]

Lawrence F. Smith

There is a tendency to consider wild animals as dangerous reservoirs of parasites that affect man and domestic animals, but often with little or no real basis. This sometimes makes the proper utilization of wildlife difficult. Wildlife managers, therefore, find it advantageous to possess knowledgeof such parasites. This paper presents the results of a survey of the internal parasites of the northern plains red fox (*Vulpes regalis*) in Iowa.

There is little literature dealing specifically with parasites of wild foxes. The best single source of information is the key-catalogue of Stiles and Baker (1935) which reports the following internal parasites in *V. fulva* of eastern North America: *Alaria arisaemoides, Cryptocotyle lingua, Opisthorchis conjunctus, Parametorchis intermedius, Pseudamphistomum conus, Ancylostomidae, Capillaria plica, Eucoleus aerophilus, Toxascaris limbata, Toxocara canis, T. cati, T. marginata, Trichuris vulpis, Uncinaria polaris,* and *U. stenocephala.*

In a more popular paper, Riley and Christenson (1931) mention the following as reported from foxes, but the host species and localities are omitted: *Isospora* sp., *Mesocestoides lineatus, Ancylostoma caninum, Uncinaria stenocephala, Toxocara canis, T. mystax, Tosascaris leonina, Eucoleus aerophilus,* and *Spirocerca lupi.*

Monnig (1934) names the parasites of the European *Vulpes.* Allen (1933) lists the parasites of *Vulpes,* without indicating the species and localities of the hosts. Leigh (1940) reports the following parasites found in 12 red foxes (*V. fulva*) from Illinois with numbers as indicated: *Echinoparyphium* sp., 1; *Taenia pisiformis* (?), 6; *Ancylostoma caninum,* 1; *Toxocara canis,* 12; *Trichuris* sp., 1. Goble and Cook (1941) examined the lungs of 40 red foxes (presumably *V. fulva*) and 12 gray foxes trapped in November and December, 1940, in New York; *Eucoleus aerophilus* was present in the trachea and larger bronchi of 22 red foxes and *Crenosoma vulpes* in the bronchi of 6 red foxes and 2 gray foxes. Several other publications deal with the parasites of the economically more important silver fox, including those by Cameron (1934) and Shillinger (1937).

Materials and Procedure

For this study 234 skinned carcasses of adult foxes were collected from Iowa in December to February of 1938–39, 1939–40, and 1940–41. Those used in 1938–39 were obtained by Thomas G. Scott while investigating the life history and ecology of the red fox. The parasites found were kindly lent for examination. The writer personally procured and examined the fox carcasses during other

[1] Journal Paper No. J-970, Iowa Agricultural Experiment Station, Ames, Iowa; Project No. 570. The U. S. Fish and Wildlife Service, Iowa State College, Iowa State Conservation Commission, and the American Wildlife Institute cooperating.

E. R. Becker, Iowa State College, gave helpful supervision; Thomas G. Scott, U. S. Fish and Wildlife Service gave counsel and cooperation; and E. W. Price, U. S. Bureau of Animal Industry, and C. T. Green, U. S. Bureau of Entomology and Plant Quarantine, made certain identifications. Officers of the Iowa State Conservation Commission helpfully suggested sources of material in the field.

two winters of the work. Data were obtained for 141 males, 86 females, and 7 of undetermined sex. Of the carcasses, 44 were from three counties in northeastern Iowa, 14 from two southeastern counties, and the remainder from 22 counties rather evenly distributed over the western half of the state.

Most of the animals had been dead for several days. Consequently, the blood and intestinal contents were not examined for protozoa other than the oocysts of coccidia. A small piece of each diaphragm was preserved in formalin and later examined microscopically for cysts of *Trichinella spiralis*. The organs, cavities and contents examined for parasites included the lungs, gall bladder and bile duct, urinary bladder, diaphragm, stomach, small intestine, and large intestine.

The stomach, small intestine, and large intestine were each slit open. The small intestine was placed in a large (8″ diameter) flat-bottomed glass dish half-filled with water. Starting at one end, the examiner drew the flat ribbon formed by the opened intestinal tube, inner side up, between the edge of the vessel and the index finger; thus the contents were rubbed from the surface and fell back into the dish. The cleaned inner surface of the intestine was scrutinized as it left the dish to detect any parasites which might have escaped dislodgment. The contents of the dish were poured into a bottle and shaken vigorously to disintegrate the material. The resulting soupy suspension was poured onto a fine (No. 40) mesh brass screen and well flushed with clean water. The remaining material was next washed from the screen, caught in a large pan and returned to the glass dish. The latter was placed on a black background. The washing eliminated turbidity and any parasites were then seen readily. The stomach was laid flat, inner side up, in water on the bottom of a dish like that used for processing the small intestine. The inner wall was then rubbed to loosen the clinging material, and the substances thus freed were screened, washed, and inspected for parasites.

Fecal material from the upper part of the large intestine was examined macroscopically and microscopically for coccidia and other parasites.

RESULTS AND DISCUSSION

Table 1 summarizes the findings of this study. The parasites listed were taken from 167 (*71.3%*) of the foxes examined. In some animals, only one parasite of a species was present, in others two or more. One fox pup, killed in April 1938, and estimated to be three or four weeks of age, contained two specimens of *Toxocara canis*.

NEMATODES

Toxascaris leonina was by far the most important parasite by frequency of occurrence. It was usually in the small intestine, particularly in the duodenum. Male foxes were more heavily parasitized than females as shown in the following summary:

Foxes	*Number infested*	*Incidence of infestation*	*Average number of worms per infested fox*
Male	90	*63.8%*	25.3
Female	47	*54.6%*	15.8

Whether the striking difference in the worm counts for the two sexes actually represents a difference in susceptibility is, of course, open to question, but Curtis, Dunning, and Bullock (1923) did show that male rats were less resistant than female rats to cysticercus in-

Table 1.—PARASITES FROM 234 RED FOXES IN IOWA.

Name of parasite and principal habitat	*Total Specimens*	*Foxes infested*	
		No.	*Per cent*
NEMATODES:			
Toxascaris leonina small intenstine	2,924	140	*59.8*
Physaloptera felidis stomach	262	80	*34.2*
Toxocara canis small intestine	47	21	*9.0*
TRICHOSTRONGYLINAE small intestine; accidental	1	1	*0.4*
Cruzia sp. stomach; accidental	15	1	*0.4*
Ancyclostoma caninum small intestine	1	1	*0.4*
CESTODES:			
Taenia sp. small intestine		1	*0.4*
Taenia sp. small intestine		41	*17.5*
Mesocestoides sp. small intestine		1	*0.4*
Cittotaenia pectinata small intestine; accidental?		1	*0.4*
COCCIDIA:			
Isospora sp. intestine		1	.4
Isospora sp. intestine		1	.4
INSECTS:			
Piophila casei (L.) intestine; accidental		1	.4
Hoplopsyllus affinis fur		1	

fection when fed taenia eggs, and in experimental rats Campbell (1939) found infestation of females with *Cysticercus crassicolis* to be only 60 to 80 per cent that of males.

There was considerable variation in the prevalence of *T. leonina* in foxes from different regions of Iowa as follows:

Region	*Foxes*	*Incidence*
Northeast	42	*100%*
Northwest	79	*70%*
Southwest	60	*57%*
South-central	21	*14%*
Southeast	12	*8%*

The average number of worms per fox varied, roughly, with the regional incidence.

The ratio of males to females of *T. leonina* (all specimens found) was 75.7:100. The preponderance of females occurred in both sexes of the host.

An explanation of the difference in incidence of *T. leonina* and *Toxocara canis* (see below) possibly may be drawn from the results of experiments by Wright (1936) who found that ova of *T. leonina* withstood greater extremes of temperature and desiccation than did those of *T. canis*.

Physaloptera felidis was the second most numerous parasite and usually found in the stomach. Female worms were more numerous than males. The relative abundance in the two sexes was as follows:

Foxes	*Number infested*	*Incidence of infestation*	*Average number of worms per infested fox*
Male	54	*38.3%*	5.4
Female	25	*29.9%*	2.8

Toxocara canis was represented by 47 specimens in 21 foxes, an incidence of 9.0 per cent. They were mainly in the small intestine. Twenty of the 21 infested foxes were males. One specimen belonged to the Trichostrongylinae, a group common in rodents; its occurrence in a fox possibly was accidental. Fifteen specimens of *Cruzia* sp. were found in one fox. Worms of this genus occur in oppossums, reptiles, and amphibians, and possibly their presence in the fox was secondary. *Ancylostoma caninum* was represented by one specimen; no other hookworm was found.

CESTODA

Two species of *Taenia* were found, one in a single fox and the other in 41

animals. The second was present in 31 males (incidence, 22%) and 10 females (incidence, 12%). Usually only fragments of tapeworms were recovered and the number of complete worms represented is unknown. More tapeworm "material" was found, on the average, in infested male foxes than in females. There was one specimen of *Mesocestoides* sp., and one of *Cittotaenia pectinata*. The latter is common in rabbits. Its presence here was probably a result of ingestion.

The fox might be host to the adult stage of the hydatid tapeworm (*Echinococcus granulosus*), the cyst of which is a dangerous parasite in man, but none of these worms was found in the present study. Cameron (1934) states that this cestode occurs naturally in wild foxes and dogs. Edney (1940) reports it in 2 of 40 dogs examined in Tennessee. Riley (1939) states that in 12 timber wolves (*Canis lupus lycaon*) from Minnesota (8 of them from the northeastern part of the state) 5 of the 8 harbored adults of *E. granulosus*. In 26 coyotes (*Canis latrans*), 25 gray foxes (*Urocyon cinereoargenteus*), and 25 red foxes (*Vulpes fulva*), he found none. In 21 moose examined from northeastern Minnesota he found 11 to have hydatid cysts in the lungs.

Only one hookworm (*Ancylostoma caninum*) was found, suggesting that the red fox in Iowa is not an important reservoir for this nematode. *A. caninum* is the species to be expected in this region according to Cameron (1934) who states that *Uncinaria stenocephala* infests dogs and foxes in northern Canada but is replaced by *A. caninum* in southern Canada and in the United States.

COCCIDIA

Oocysts of coccidia were found in fecal samples from two foxes. Both belonged to genus *Isospora*, but apparently were of different species. Both infections were light and no effects on the intestinal wall were noted. The identity of one of the species was sought by measuring 113 oocysts. They were 29.2 (28.6 to 43.6) microns in length and 35.2 (24.3 to 33.6) microns in width. Of the descriptions found in literature, that of a coccidium found by Weidman (1915) in the swift fox of the western United States most nearly applies to the form found here. His measurements were 28 (25 to 30) microns by 33 (27 to 40) microns. Weidman proposed the new varietal name, *canivecolis*, for what he inferred to be a variety of *Coccidium bigeminum*. Wenyon (1923) found many oocysts of *Isospora felis* to measure 45 (39 to 48) microns by 33 (26 to 37) microns. He states that Weidman's coccidium is certainly not a variety of *C. bigeminum* and may or may not be distinct from *Isospora felis*. If distinct, Wenyon points out that the name *Isospora canivecolis* would be correct. This may be the species of the present study.

INSECTA

Four dipterous larvae extracted from the intestine of one fox were of the cheese skipper (*Piophila casei*), which occurs on various kinds of cheese, cakes, and smoked meats and were probably ingested with garbage. Several specimens of a flea (*Hoplopsyllus affinis*) were taken from the fur of one unskinned animal.

The subject of red fox control fre-

quently takes on controversial proportions. The argument that foxes harbor parasites dangerous to man and domestic animals might be advanced by pro-control groups. In the light of this survey it does not appear that control measures would be justified for that reason. The only common parasite (*Toxascaris leonina*) is well established among domestic canines and a small reservoir of it in wild foxes would be unimportant. The same is true of the less common *Physaloptera felidis* and *Toxocara canis*.

SUMMARY

During three consecutive winters starting with 1938–1939, a survey was made to determine parasites of the red fox (*Vulpes regalis*) in Iowa, the number of each kind of parasite per animal, and the percentage infested. The following organs were examined in 234 carcasses: lungs, gall bladder, bile duct, urinary bladder, diaphragm, stomach, small intestine, and large intestine.

The natural parasites included *Toxascaris leonina*, *Physaloptera felidis*, *Toxocara canis*, *Ancylostoma caninum*, *Taenia* (two species), *Isospora* (two species) and *Mesocestoides* sp.

The parasite population was somewhat greater among male foxes than among females; the incidence of the *Toxascaris leonina* infestation showed significant geographic variation; and females of the most prevalent nematode (*Toxascaris leonina*) were more numerous than males.

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THE "HUMANE COYOTE-GETTER" VS. THE STEEL TRAP IN CONTROL OF PREDATORY ANIMALS

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Consideration of the selectivity, safety, humaneness, and general efficiency and economy of control methods before they are placed in operational use is a principle upon which the U. S. Fish and Wildlife Service has operated, and its Wildlife Research Laboratory at Denver has played an important part in the determination of the facts. In conformity with this policy, the "Human Coyote-getter," a device for coyote control, has been subjected to field tests for over a year in three western states. The trials were made to reveal its inherent advantages and disadvantages, and to compare it with the steel trap.

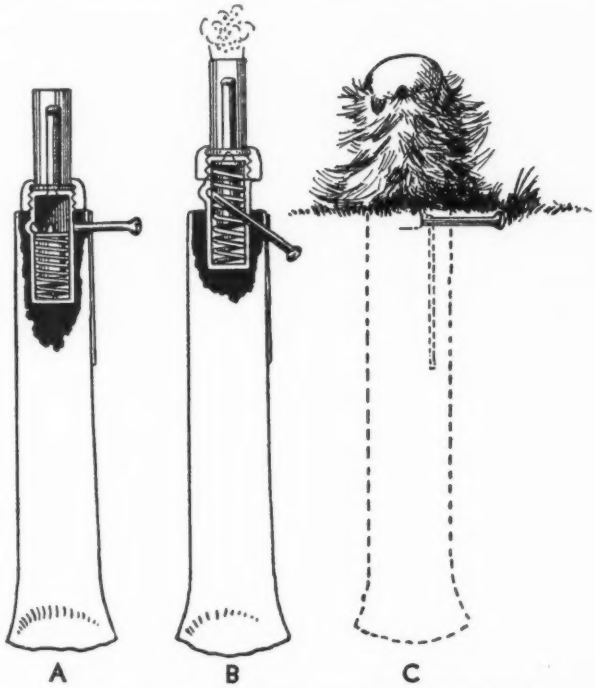

Fig. 1. Coyote-getter, one-half natural size. (A) Parts of the device. (B) Action upon being discharged. (C) The device as covered with rabbit fur and properly set.

The coyote-getter (patent pending; privately manufactured) injects a poison, sodium cyanide, directly into the coyote's mouth. It consists of (Fig. 1, *A*)[1] (1) a hollow metal stake, closed by crimping at the bottom, (2) a release

[1] Illustrations contributed by E. R. Kalmbach, Director of the Laboratory.

or firing mechanism, (3) a cartridge holder, and (4) a poison-ejecting cartridge. In setting, the stake is driven full length into the ground, the release mechanism is fitted into the top of the stake, and the .38 calibre cartidge pointing upward is inserted into the holder and covered with an attractant such as rabbit fur or wool to form the "bait" and then attached to the top of the release or firing mechanism. A fetid scent is smeared on the top of the bait as an additional lure. When the "set" is completed, the bait, about the size and shape of a man's thumb, protrudes above the ground and is the only part of the device visible. Should the bait be raised a fraction of an inch the release mechanism discharges the cartridge and the poison is driven upward through the ruptured fur or wool with considerable force. Any animal, impelled either by curiosity or the desire for food, that grasps the bait in its teeth and pulls upward receives the discharge of poison directly in its mouth. The animal is frightened by the explosion and generally leaves the spot hurriedly but usually succumbs when 100 to 200 feet away, since the poison acts very rapidly.

METHODS OF STUDY

The writer, with the generous assistance of hunters of the Division of Predator and Rodent Control of the U. S. Fish and Wildlife Service conducted studies with this new control device as follows: (1) Comparing the efficiency and selectivity of the coyote-getter and the steel trap in the field at all seasons under the same climatic, environmental and trapping conditions; (2) determining its selectivity by additional catch records while the device was being used on an operational scale; and (3) comparing control results of one hunter using steel traps and another using coyote-getters.

The experiments were conducted in Wyoming, Colorado, and New Mexico from September, 1940, to September, 1941, inclusive. Records were kept of the performances of the cotyote-getters and of steel traps on the plains east of and adjacent to the Rocky Mountains, on sagebrush plateaus and desert areas, in valleys, and on foothills and mountains up to 13,000 feet in elevation. Thus the relative merits of the two were studied in areas representative of all conditions under which predator control is carried on in these states. To determine the relative merits of the two devices, the experiments were occasionally conducted in habitats where the catches of non-predators by one or both of the devices were abnormally high, and in areas where experience indicated that use on an operational scale might be hazardous and unwise.

Six to ten competent hunters maintained lines containing both traps and coyote-getters. A strict alternation of sets (coyote-getter followed by trap) was adhered to on some lines, while on others coyote-getters and traps were placed in set locations best adapted to each device irrespective of alternating order. The results from 82,820 trap-set days and 107,215 coyote-getter days were recorded. Experiments were in progress during 13 months, but involved only a year since few hunters had experimental lines at the beginning and end.

There are some shortcomings in such comparative tests because operation of the two control implements varies

somewhat. In the first place, steel traps must be tended regularly every few days; coyote-getters, which kill the animals soon after being discharged, need not be tended as often. Hence the operator of coyote-getters obtains greater effectiveness by setting out more and longer lines and allowing each line a greater time to operate between visits. Also the ease of setting and tending coyote-getters reduces the time required to maintain a line, with the result that more sets may be made and the chances of taking predators increased. But to determine the efficiency and selectivity of the two methods, it was necessary to test them under exactly the same conditions and to do so meant the mixing of sets and handling the combined series as a line. Furthermore, the trappers were competent in trap usage by long experience, but relatively inexperienced in operating coyote-getters. Able trappers generally have no difficulty in using coyote-getters, yet greater efficiency comes with experience. Hence, if there was any advantage in these comparative tests, it rested with steel traps.

EFFICIENCY IN TAKING PREDATORS

In 82,820 trap-set days (either single or double sets), 325 coyotes and 32 bobcats were captured; and in 107,215 coyote-getter days (all single sets), 419 coyotes and no bobcats were killed and recovered (Table 1). An average of 254.8 trap-set days were necessary to capture a coyote with traps, and of 255.9 coyote-getter days for each coyote killed and recovered with coyote-getters. Thus, over the entire year the coyote-getter was essentially as effective (99.6%) as the trap in the capture of coyotes. The traps also captured 32 bobcats, making a total of 357 predators with 232 trap-set days per predator. Bobcats rarely discharge coyote-getters and only two were taken in this study (in an estimated 288,000 days of coyote-getter exposure). Considering the capture of predators of both types, the coyote-getter was 90.6 per cent as effective as the trap; differences in the efficiencies of the two devices are due largely to the margin of bobcats taken with traps.

Table 1.—RELATIVE EFFICIENCIES OF TRAPS AND COYOTE-GETTERS IN THE CAPTURE OF PREDATORS; SEPTEMBER, 1940, TO SEPTEMBER, 1941.

	Traps	*Coyote-getters*
Number of set-days	82,820	107,215
Coyotes taken	325	419
Bobcats taken	32	0
Total predators taken	357	419
Set-days per take		
Coyote	254.8	255.9
Bobcat	2588.1	—
Predator	232.0	255.9
Relative efficiency for		
Coyotes	*100%*	*99.6%*
Bobcats	*100%*	*0.0%*
Predators	*100%*	*90.6%*

The number of coyotes that discharge coyote-getters and are recovered by the hunters is less than the number actually killed; 584 coyote-getters were discharged by coyotes and 419 of the animals were found. The 165 not recovered represent 28.2 per cent of the coyotes that discharged coyote-getters. Some of these undoubtedly escaped and others were killed but not found. On the basis of a large number of records gleaned from actual operations with the coyote-getters, coyotes recovered

were found at an average distance of 73 yards from the sets, but some individuals travelled as far as 600 yards before death. Hunters obviously cannot find every coyote within a radius of 600 yards from the set, particularly in rough or brush-covered country. Frequent reports of sheep herders, hunters, and others finding dead coyotes near sets where the trappers have failed to recover coyotes justifies the conclusion that more are killed than recover.

Table 2.—RELATIVE EFFICIENCIES OF TRAPS AND COYOTE-GETTERS DURING VARIOUS TRAPPING PERIODS.

	COYOTES				PREDATORS (coyotes and bobcats)			
	Trap-set days per coyote	Coyote-getter days per coyote	Efficiency index traps	Efficiency index coyote-getters	Trap-set days per predator	Coyote-getter days per predator	Efficiency index traps	Efficiency index coyote-getters
September-October, 1940	138.9	161.6	*100*	*85.9*	128.8	161.6	*100*	*79.7*
November, 1940	343.6	224.7	*100*	*152.9*	327.2	224.7	*100*	*145.6*
December, 1940–March, 1941	524.5	304.7	*100*	*172.1*	455.1	304.7	*100*	*149.3*
April–May, 1941	760.0	343.9	*100*	*221.0*	608.0	344.0	*100*	*176.8*
June–August, 1941	213.2	321.0	*100*	*66.4*	188.4	321.0	*100*	*58.7*
September, 1941	123.4	182.7	*100*	*67.5*	121.3	182.7	*100*	*66.4*

In November weather conditions were generally unfavorable for traps and in some instances for coyote-getters; the relative efficiencies of the two devices were then reversed—coyote-getters being 152.9 per cent as effective as traps for coyotes. Difficult winter trapping conditions were experienced from December, 1940, to March, 1941, and reduced the efficiency of the traps more than the coyote-getters. Traps then captured a coyote every 524.5 trap-set days and coyote-getters accounted for one every 304.7 days. During April and May the weather was more favorable for both devices, but the field workers then were hunting dens and could devote less time to maintaining their lines. The traps accounted for a coyote every 760.0 days and coyote-getters every 343.9 days. The lower efficiency of traps during this period was due primarily to less frequent tending of lines and not to inclement weather. In June, July, and August trapping conditions were favorable, covered. The coyote-getter, therefore, is more effective than the trap in coyote control even though the figures given previously show the coyote-getter to be slightly inferior to the trap in respect to the actual number of animals recovered.

EFFECTS OF VARIOUS TRAPPING CONDITIONS

The relative efficiencies of the two devices were compared also under different trapping conditions (Table 2). During September and October, 1940, the weather was generally favorable for the operation of both, and coyote-getters were 85.9 per cent as effective as traps in the capture of coyotes and 79.7 per cent as effective in taking predators of the two species. In November weather

and the averages were 213.2 days per coyote by traps and 321.0 by coyote-getters. Thus the relative efficiencies of the two devices again were reversed. During September, 1941, conditions still were favorable for both traps and coyote-getters, the traps maintaining higher efficiency.

On the basis of the above figures the lesser extent, by reduced predator populations, but the catches with coyote-getters were affected only by the normal reduction in numbers of predators. From December to March the catches with both devices became progressively smaller because of the diminishing supply of predators, those by traps being below those of coyote-getters. During

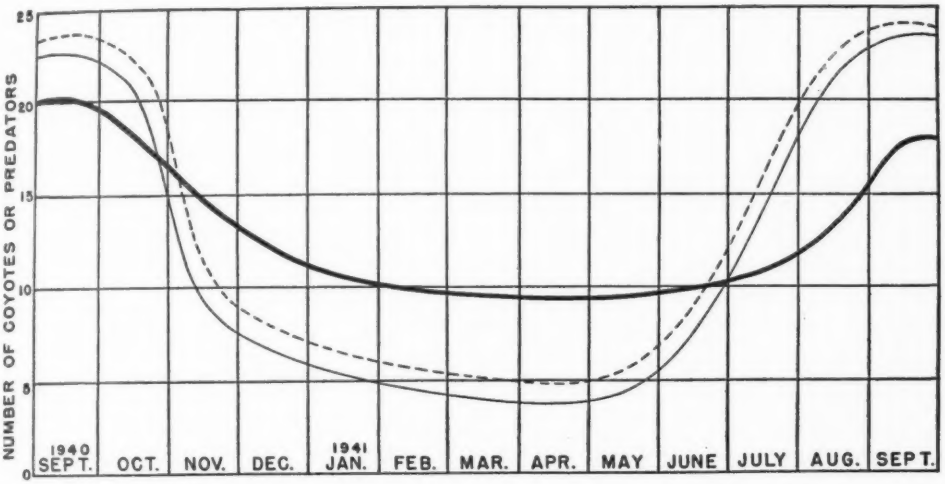

Fig. 2. Comparison of coyotes and predators (coyotes or bobcats) taken with 100 trap sets and 100 coyote-getter sets, September, 1940, to September, 1941, inclusive. ———, coyotes with traps; - - - - - -, predators (coyotes plus bobcats) with traps; ———, coyotes with coyote-getters.

numbers of coyotes and predators that could be taken with 100 trap sets and 100 coyote-getter sets in 13 months are shown in Figure 2. With predators numerous and control conditions favorable during September and October, both traps and coyote-getters captured maximum numbers, the traps making larger catches. With gradual reduction in predators and unfavorable trapping weather during November, the traps took fewer than the coyote-getters. The efficiency of traps was affected primarily by inclement weather and, to a April and May both devices captured a minimum; the numbers of predators susceptible to capture by traps or coyote-getters then were at the lowest levels. The weather for trapping improved during this period, but catches with traps did not increase correspondingly because the trappers were hunting dens. The less frequent attention given the lines did not materially affect the coyote-getters.

The larger predator populations and improved trapping conditions during June, July, and August resulted in

greater catches with both devices. As young coyotes began to travel greater distances from the den sites, the catches increased accordingly. During June more attention was given to trap and coyote-getter lines, whereupon traps took more coyotes and predators than coyote-getters. During September, 1941, with greater movements of the coyotes and favorable trapping conditions, catches such as those during September and October, 1940, were made.

Thus catches with traps were greater than with coyote-getters from June to October, but the reverse was true from November to May. When the traps were more effective (June to October) the catches were high with both devices because of the abundance of predators, but when the coyote-getter was more effective (November to May) the catches with both devices were lower due to the scarcity of predators. Thus, during five months of trap superiority the traps established a margin in the number of animals taken that was not surpassed by the coyote-getters in the seven months when traps were less effective.

AGE CLASSES OF COYOTES TAKEN

The coyotes taken were classified into three age groups (Table 3): (1) pups, young less than a year old; (2) mature, in the prime of life with no wear of canine teeth; and (3) old coyotes, with definite wear of canine teeth.

The criteria for age classification are indefinite and subject to error; nevertheless, with the same men classifying the catches from both traps and coyote-getters, the results are comparable. The two devices take nearly the same proportions of old coyotes, but coyote-getters take fewer pups and more mature coyotes than do traps. These differences relate to the period during which each device was most efficient. When pups were most abundant and easily identified (June to September) traps took a majority of the coyotes.

Table 3.—AGE CLASSES OF COYOTES TAKEN.

	With Traps	
	Number	*Per cent*
Pups	138	*42.5*
Mature	123	*37.8*
Old	63	*19.4*
Unclassified	1	*0.3*
Total	325	

	With Coyote-getters	
	Number	*Per Cent*
Pups	136	*32.5*
Mature	210	*50.1*
Old	68	*16.2*
Unclassified	5	*1.2*
Total	419	

For the remainder of the year pups were scarcer and acquiring the characteristics of mature coyotes; coyote-getters then made a majority of the kills. During the latter period accurate differentiation between pups and mature coyotes was difficult and many less than a year old probably were classified as mature. Differences in the percentages of pups and mature animals taken with traps and with coyote-getters, therefore, may result from the unequal numbers of pups present and the ease or difficulty of age classification during the period when each device was taking a majority of the coyotes.

SELECTIVITY

The traps also killed 441 non-predatory creatures, but the coyote-getters accidentally killed only 26 (Table 4).

The coyote-getter was more selective in the killing of coyotes than the trap and much less destructive to other animals except domestic mammals; in that respect the coyote-getter approached the trap. The coyote-getter was more destructive to dogs and bears (and cattle on the basis of other experiences). Six cattle were killed with coyote-getters in the spring of 1940 and another during the summer of 1941. Coyote-getters, however, were less destructive than traps to small mammals, birds of prey, ground nesting birds, deer, antelopes, and domestic sheep. These creatures are exposed to injury or death in areas densely set with traps.

Non-predators are released from traps whenever practicable, but some die while confined in the traps and others, being crippled, are destroyed for humanitarian reasons. Ordinarily no effort is made to release skunks and creatures generally classified as pests; hence the number of "fur-bearers" and "other creatures" killed in trapping operations is considerable.

A total of 192 non-predatory creatures caught in traps either were released, extricated themselves by leaving a foot in the trap, or escaped with the trap (Table 5). With respect to injuries by coyote-getters, it is judged from the evidence at hand that these devices injure no other creatures—this assumption is based upon the belief that no permanent injury results if an animal or bird is not killed by discharging the coyote-getter.

A few of the creatures injured and released from traps may have died as a result of their injuries, particularly deer and antelope that escaped with traps and some other creatures released but permanently injured.

Table 4.—NON-PREDATORY ANIMALS AND BIRDS KILLED IN CONTROL OPERATIONS.

	Traps	*Trap-set days per kill*	*Coyote-getters*	*Coyote-getter days per kill*	*Trap index (per cent)*	*Coyote-getter index (per cent)*
Number of set-days	82,820		107,215			
Animals killed						
Game[1]	13	6,370.8	3	35,738.3	*100*	*17.82*
Fur-bearers[2]	74	1,119.2	6	17,869.2	*100*	*6.26*
Domestic mammals[3]	9	9,202.2	11	9,746.8	*100*	*94.41*
Beneficial birds[4]	7	11,831.4	0[5]	—	*100*	—
Other creatures[6] (considered largely pests in area studied)	338	245.0	6	17,869.2	*100*	*1.37*

[1] *Traps:* 6 antelope, 6 sagechickens, 1 bear; *coyote-getters:* 3 bears.
[2] *Traps:* 35 skunks, 33 badgers, 3 foxes, 3 raccoons; *coyote-getters:* 5 skunks, 1 fox.
[3] *Traps:* 6 sheep, 2 house cats, 1 dog; *coyote-getters:* 11 dogs.
[4] *Traps:* 4 eagles, 3 hawks.
[5] No beneficial birds were killed by coyote-getters but such accidents may occur. Later records show that two eagles and one hawk were killed during an esimated 288,000 days of coyote-getter use.
[6] *Traps:* 148 rabbits, 85 porcupines, 69 rockchucks, 21 ground squirrels, 6 magpies 5 prairie dogs, 3 turkey vultures, 1 raven; *coyote-getters:* 5 magpies, 1 crow.

THEORETICAL CATCHES

In the preceding discussions the catches of the two devices have been compared on the basis of the actual

number of set days necessary to capture an animal as determined from an unequal number of days of set activity. For simplicity the catches may be compared on a theoretical basis assuming an equal number of set-days for traps and coyote-getters. If 100 trap-sets and an equal number of coyote-getters were used continuously throughout a year, 36,500 set-days (100 sets×365 days) of activity for each would be recorded. Based on the records in Tables 1 and 4, the theoretical catches that would be made are shown in Figure 3.

On the assumptions made, the theoretical catch with traps would be 143.2 coyotes and 14.1 bobcats or a total of 157.3 predators as compared to 142.6 predators (all coyotes) with coyote-getters; 5.7 game animals would be killed with traps compared to 1.0 with coyote-getters; the traps would destroy 32.6 fur-bearers and the coyote-getters 2.0; the domestic animals accidentally killed with each would be about equal, traps, 4, and coyote-getters, 3.7; 3.0 beneficial birds would be destroyed with traps and none with coyote-getters; and 149.0 other creatures (largely pests) would be killed with traps but only 2.0 with coyote-getters.

Table 5.—NON-PREDATORS INJURED AND RELEASED FROM TRAPS AND EXTENT OF INJURY.

Game: 19	
Pheasants, temporary injury	1
permanent injury	4
Deer, no injury	2
pulled stake, loose with trap	5
Antelopes, released	1
permanent injury	2
pulled stake, loose with trap	4
Furbearers: 65	
Badgers, no injury	1
released	11
temporary injury	28
permanent injury	17
Fox, released	1
permanent injury	2
[1] "pegged"	1
Skunks, permanent injury (pegged)	4
Domestic Animals: 107	
Sheep, no injury	12
released	8
released by herder	42
temporary injury	15
permanent injury	11
Dogs, no injury	2
released	6
released by herder	5
temporary injury	3
permanent injury	3
Other Creatures: 1	
Rabbit, permanent injury (pegged)	1

[1] Escaped, leaving foot in trap.

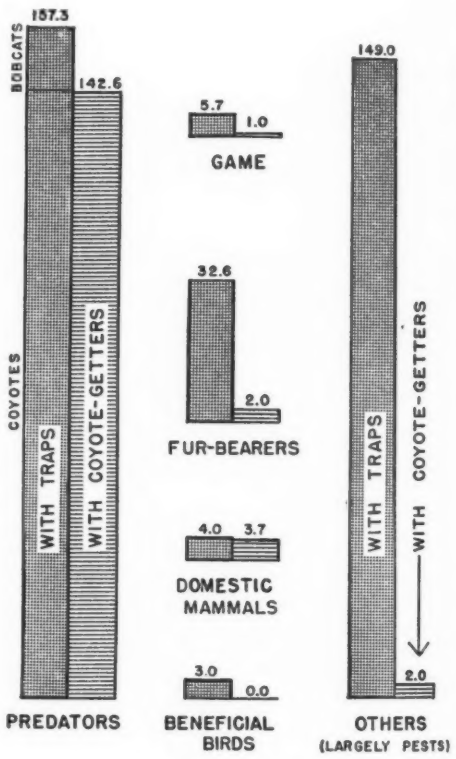

FIG. 3. Predators taken and non-predators accidentally killed in 36,500 representative steel trap-set days and 36,500 representative coyote-getter days.

ADDITIONAL COYOTE-GETTER RECORDS

In addition to the records which have been discussed, other hunters used coyote-getters on an operational scale from September, 1940, to September, 1941, and submitted reports on their daily catches (Table 6). Of the 1,169 creatures killed by discharging these coyote-getters, 1,109, or 94.9 per cent, were predators, while 60, or 5.1 per cent, were non-predators. In addition to the skunks killed by springing the devices, two others were poisoned by chewing discharged cartidges. In two instances a coyote and a skunk were found dead near a discharged coyote-getter, and it was assumed that the coyote had sprung the device and the skunk was poisoned from chewing the discharged cartridge.

Table 6.—ADDITIONAL COYOTE-GETTER RECORDS FROM HUNTERS IN WYOMING, COLORADO, AND NEW MEXICO, SEPTEMBER, 1940–SEPTEMBER, 1941, INCLUSIVE.

Coyote-getter days (estimated)	288,000
Individual set tendings	49,511
In operating condition	44,797
Discharged	2,060
Disturbed	2,654
Killed:	
Predators:	
Coyotes	1,107
Bobcats	2
Others:	
Dogs	24
Magpies	14
Foxes	7
Skunks	6
Skunks (killed by chewing discharged cartridges)	2
Badgers	2
Eagles	2
Bears	2
Hawks	1
Rockchucks	1
Cow (yearling heifer)	1
Not killed (or, if killed, not recovered):	
Predators:	
Coyotes	581
Non-predators:	
Cattle (11 by licking)	13
Cattle, stepping on trigger	7
Magpies	51
Sheep, stepping on trigger	39
Mice	10
Horses, stepping on trigger	5
Rockchucks	2
Dogs	2
Others:	
Unknown	162
Road graders	18
Man (fired by rabbit hunter)	1

It is probable that few non-predators, other than these listed as casualties, succumbed as a result of discharging coyote-getters since these creatures are incapable of leaving the set with the speed of the coyote and if killed are likely to be found more easily than a coyote. Dead non-predators are always recovered in the immediate vicinity of coyote-getter sets.

COYOTE-GETTERS VS. TRAPS ON SEPARATE LINES

To determine the relative control potentialities of coyote-getters and traps, the results of one hunter using steel traps exclusively were compared with those of another using only coyote-getters. The men operated at the same time of year in adjoining areas estimated to have equal predator infestations.

In appraising the control results by the two methods from an operational standpoint, the determining criteria are the miles of line maintained, the approximate areas embraced, and the numbers of predators taken with each type of device. During the autumn, when travelling conditions were favorable, the man using coyote-getters maintained about 60 per cent more miles of line, covered over 42 per cent more area, and took 57 per cent more predators than the man with traps. During the winter, when weather conditions were difficult and travel was

restricted, the hunter using coyote-getters maintained 50 per cent more line, covered over 66 per cent more area, and took 265 per cent more predators than the man using traps.

In September, October, and November one predator was taken with traps in an average of 7.4 square miles of territory and with coyote-getters in an average of 6.7 square miles. From December to March one predator was taken with traps every 15.0 square miles of territory and with coyote-getters in 6.8 square miles. Over the seven month period the hunter using coyote-getters maintained at least 50 per cent more line, covered 50 per cent more territory, and took more than twice as many predators as the man who used traps. Assuming that the abilities of the two hunters were equal and their areas had comparable predator infestations, it is evident that the use of coyote-getters enabled a hunter to cover more territory and to effect a greater degree of control within that territory than was possible with traps.

Table 7.—COYOTE-GETTERS VERSUS TRAPS ON SEPARATE LINES: SEPTEMBER, 1940-MARCH, 1941.

	Traps		*Coyote-getters*	
	Autumn	*Winter*	*Autumn*	*Winter*
Devices used	307	184	425	350
Sets used	157	92	425	350
Set tendings made	2,158	2,228	3,897	5,099
Miles of line maintained	202	149	325	225
Approximate area (square miles) embraced with lines	540	300	770	500
Animals taken				
Coyotes	73	15	115	73
Bobcats	0	5	0	0

DEFECTS OF THE COYOTE-GETTER

Some unfavorable features of the coyote-getter must be considered. First, the device may be sprung accidentally by the trapper or by others and the possibility of a severe injury or even a fatality is greater than with the trap, although no serious accidents have occurred. This is fully recognized in field operations by placing coyote-getters away from travelled highways, by adequately posting areas where they are used, and by instructing the trappers who use the coyote-getters as to the proper methods of operating them, such as the wearing of gloves and keeping other parts of the body from above the devices when handling them.

Second, there is a considerable loss of pelts because not all of the animals killed are recovered and much of the fur spoils during periods of warm weather. In this respect the coyote-getter is similar to the poison station, whereas the trap usually permits the salvaging of the furs.

Third, the coyote-getter, and particularly the cartridge, needs further improvement. Inadequate firings and deterioration of the poison within cartridges have resulted in many failures and probably have "educated" some coyotes against further association with the device. Continued failures of the implement are certain to lower the effi-

ciency of this method of predator control.

SUMMARY

The merits and shortcomings of an implement known as the "humane coyote-getter" have been compared with those of the steel trap in studies over 13 months in Wyoming, Colorado, and New Mexico.

In actual days of operation over the entire period, the trap was slightly more efficient than the coyote-getter in the capture of coyotes and about 10 per cent better in the capture of predators generally. The coyote-getter was ineffective for control of bobcats, and the difference in the relative efficiencies of the two devices for the capture of predators as a group was due primarily to the number of bobcats taken with traps. Considering the control of coyotes rather than the actual number of pelts or scalps recovered, the indications are that the coyote-getter was more effective than the trap because many coyotes killed by discharging coyote-getters were not recovered.

When trapping conditions were favorable (June to October) the coyote and predator catches with traps were greater than those with coyote-getters, but during the remaining seven months of less favorable trapping conditions the reverse was true. The coyote-getter was particularly valuable when frozen ground impeded the action of traps.

The coyote-getter was generally much more selective than the trap for the capture of coyotes. It was less destructive to small mammals, birds of prey, ground nesting birds, deer, antelopes, and domestic sheep, but more destructive to dogs, bears, and cattle. From evidence acquired elsewhere it appears that the coyote-getter may be too dangerous to livestock for general use in cattle country.

Of the creatures killed and recovered with coyote-getters, about 95 per cent were predators.

The control potentialities of the coyote-getter appear to be greater than those of the trap because the operator of the former is unhampered by freezing weather, rodents, game, or sheep, does not need to make as frequent visits to sets, and can maintain more sets than is possible with traps. A hunter equipped with coyote-getters covered a larger territory and effected a greater degree of control within that territory than a comparable hunter equipped with traps was able to do in a similar adjoining area.

The killing action of the coyote-getter is very rapid. An animal that discharges the device is found usually within 75 yards from the set, and the time from discharge until unconsciousness ensues is normally less than one minute.

The coyote-getter, if accidentally discharged, is a potential hazard to human beings including the user; there is a loss of pelts not recovered before spoilage; and the implement itself needs further improvement.

In large scale operational control of coyotes, the coyote-getter should be considered as an adjunct to but not a substitute for the steel trap.

COLOR MARKING OF MAMMALS, WITH SPECIAL REFERENCE TO SQUIRRELS[1]

William D. Fitzwater, Jr.

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The marking of wild mammals to permit the recognition of individuals under field conditions has not received the attention that its potential value would seem to warrant. Field identification of marked individuals has many advantages, chiefly in studies of movements, as migrating and cruising radii can be determined most effectively and other ecological problems can be solved. Courtship, mating, family relationships, populations, and behavior patterns of individuals are some subjects upon which we may gain more light by devising reliable means of recognizing individuals.

The commoner methods of marking, such as ear-tagging, mutilating toes and ears, ringing, clipping fur, and applying pyralin markers or stains have been described chiefly in the last two decades. The resulting marks usually are not recognizable at a distance and the animals must be recaptured for positive identification because it is not easy to devise marks that are both permanent and conspicuous, yet have no toxic or hampering effect on the animals.

One means to overcome this difficulty is to apply a dye or stain to the fur which will remain conspicuous until the molt. Its effectiveness is thus limited to less than six months, but in conjunction with ear-tags or mutilation it increases the returns many fold. Several dyes and stains have been tried on mammals. Mohr (1934) attempted to stain bats with haematoxylin; Gordon (1938) found that picric acid crystals dissolved in 5 per cent formalin gave ground squirrels distinctive marks lasting until the molt; Hamilton (1939) tried waterproof inks on red squirrels with indifferent results; and Baumgartner (1940) found histological stains such as gentian violet and Biebrich scarlet to be very transitory on fox squirrels.

Of these experiments, only those with picric acid gave much promise; it produced a brilliant yellow on white fur, but was too faint to be of value on darker pelages. Results worth reporting were obtained by the writer with a commercial fur dye (*Nyanzol A*, manufactured by the Franklin Import & Export Co., 213 Water Street, New York, N. Y.)

This dye was applied to deer mice, chipmunks, red and gray squirrels, woodchucks, and rabbits. It took effect uniformly over the various white, gray, and brown shades of these species (except on the dorsal stripes of chipmunks) and produced a dark purplish-black that was clearly distinguishable. The marks persisted for four to six months on the squirrels, chipmunks, and deer mice, lasting until the animals molted, and were visible up to 25 yards. The dye does not interfere with movements of the animals and appears to be non-toxic since treated individuals licked the wet fur without apparent ill effects.

[1] Paper No. 1, Scientific Journal Series, Litchfield-Morris Wildlife Sanctuary, Litchfield, Conn. Preliminary work under R. T. King, Roosevelt Wildlife Forest Experiment Station, Syracuse, New York, on the Huntington Forest Wildlife Experiment Station.

The next problem was that of handling the live animals and this eventually was solved with the aid of two devices: A zipper tube as devised by Shadle and Skarupinski (1935), and a marking board suggested by Prof. R. T. King. The tube (Fig. 1) is a cone of light-weight canvas, open at both ends, with zipper starting at the smaller end and extending the whole length. The tube is of sufficient size at the larger end to be slipped easily over the door of a trap and tapers to a one-inch opening at the other end. The length may vary; 24 inches is most convenient for squirrels. This appliance enables one to remove an animal from a trap and prepare it for marking with lessened probability of being bitten or of permitting the animal to escape.

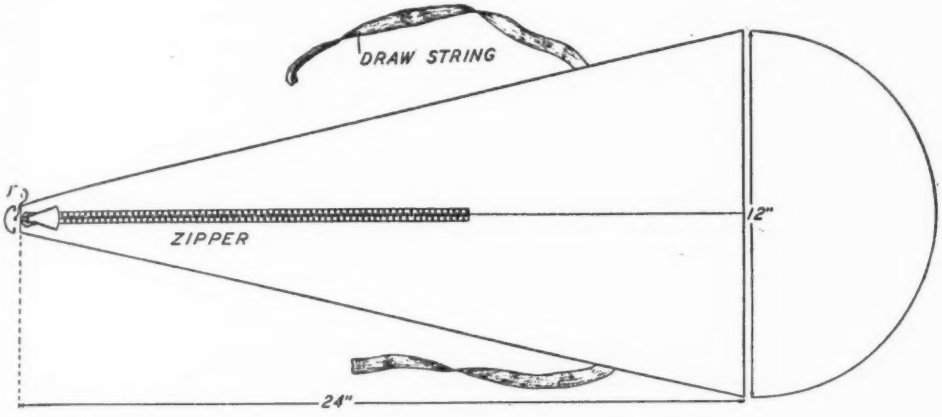

Fig. 1. Zipper tube for handling small mammals.

The marking board (Fig. 2) for squirrels comprises three pieces of $\frac{3}{4}$-inch matched lumber; two (B and C) are joined by metal strips and the third (A) slides between them. The dimensions are 20 by 15 inches, the center panel (A), however, being two inches longer than the others to aid in moving it. Notches, an inch or more in depth, are cut along the outside boards at varying distances to fit different-sized animals. One man with the aid of this board is able to hold an animal out flat and place the stain where desired.

In use, an animal is transferred from the trap to the tube and forced to the smaller end. If ear tags are to be inserted, the zipper is opened just enough to permit the head being thrust out. Then, holding the animal's neck between the second and third fingers, the rest of the zipper is pulled, releasing the animal completely from the bag. A rubber band is fastened around each leg of the squirrel by a slip loop. The use of rubber bands of different strength is necessary according to the species; bands $\frac{1}{8}$-inch wide are satisfactory for red squirrels, but $\frac{1}{2}$-inch bands are needed for the stronger gray squirrels. The animal is then "spread-eagled" on the board by fastening the rubber bands in the notches. The dye solution of 20 grams of *Nyanzol A* to 1 liter of

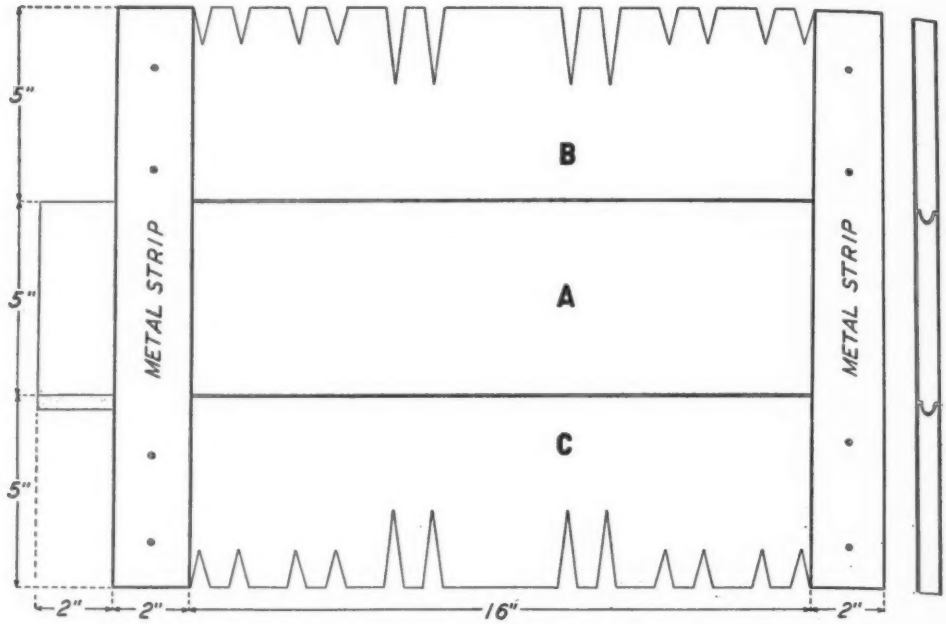

Fig. 2. Marking board for restraining small mammals.

water, previously mixed with commercial hydrogen peroxide in a ratio of 2:1, is applied with cotton swabs, using rubber gloves to protect the operator's hands.

The most effective marking is to ring the animal with broad bands. This is facilitated by the sliding center panel (A) which permits exposing the underparts without moving the animal. The best results were obtained when the body, exclusive of the tail, was marked in only three bands or regions: the "front," from the cervical region to just beyond the shoulders and including the forelimbs; the "middle," or trunk region back to the attachment of the hind limbs; and the "rear," or rump and base of the tail. The tail constitutes a fourth region.

By variously staining these four regions, and also clipping the hair from the middle of the tail (Baumgartner, 1940), 31 individuals may be distinguished. More could be marked if conspicuousness is sacrificed for variety.

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FOX SQUIRRELS IN OHIO

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Habitats

Through most of its range in Ohio, the fox squirrel (*Sciurus niger rufiventer*) inhabits small farm woodlots, of 5 to 300 acres. The larger areas usually comprise several adjoining small woodlots. In small barnyard woodlots of one-half to five acres, the squirrels usually depend upon an artificial food supply, such as corn from a corn crib or feed thrown out to live-stock. In the more heavily forested regions of southeastern Ohio they live in larger blocks of timber, along the forest edge and on open ridge-tops with much white or red oak.

TYPICAL HABITAT

A typical habitat consists of a wooded area of five or more acres containing at least twenty trees per acre, mostly oaks. The habitats throughout the state are characterized by endless variety. The more uniform types occur around the prairie openings in west central Ohio and consist of bur oak-hickory with varying amounts of white oak.

To be inhabited by fox squirrels, woodlots must constitute a complete habitat providing all necessities for their daily and seasonal activities (Pl. 11). In its daily movements a squirrel rarely goes beyond the boundaries of the woodlot save to forage in an adjacent field of corn, wheat, or soybean. In stream habitats, however, a squirrel may travel longer distances along the water course. If a square mile of farm land contains 50 acres of woodland suitable for fox squirrels, only a portion can be considered as fox squirrel habitat, with the exception that if there is a food crop adjacent to the woodlot, the habitat will be enlarged to the extent that the squirrels range into the field. This increase in size is seldom greater than one or two per cent of the original wooded area.

In the following discussion it should be remembered that in Ohio the normal habitat is a small isolated entity sufficient to support a population of fox squirrels. In the hill counties these small habitats may be bounded by open fields or by a type of woodland not suitable for fox squirrels.

Studies were conducted to determine the optimum size of these woodlots for management. The conclusion drawn was that in units exceeding 10 acres, the size of woodlots is probably not as important as is their distribution. In many western counties the woodlots are so small (5 to 30 acres) and so widely separated (1 or 2 per square mile) that they can support but few squirrels and natural restocking of these areas by dispersal is difficult. The efficiency with which "shot-out" areas can be restocked depends upon how easily squirrels can move from one area to another. The squirrels avoid large open areas and tend to follow brushy or wooded fencerows. A "shot-out" woodlot therefore may be missed by dispersing squirrels if no travel lanes lead to it.

Rapid production of woodlots in the western counties is impossible, but pending the conversion of more waste

land into forest, more travel lanes between woodlots now present may be developed. By providing these, a game manager can direct the dispersals of squirrels. In eastern Ohio the woodlots are more abundant and usually connected by wooded ravines and streams; hence the restocking of "over-shot" areas is not so difficult.

HABITAT VARIATIONS

The habitat types are best considered under two headings. The oak-hickory is the preferred type in Ohio and throughout the entire range of this squirrel, being the forest type which it inhabited before extending its range into this state.

The oak-hickory areas vary in composition, and in the northwestern swamp-forest region support water-tolerant species. A typical woodlot contains pin oak (*Quercus pulustris*), swamp white oak (*Q. bicolor*), red oak (*Q. rubra*), small amounts of black oak (*Q. velutina*), shagbark hickory (*Hicora ovata*), sour gum (*Nyssa sylvatica*), sycamore (*Platanus occidentalis*), elm (*Ulmus*). ash (*Fraxinus* spp.), soft maples (*Acer*), and a few trees of associated species such as aspen (*Populus*), willow (*Salix*), and wild black cherry (*Prunus virginiana*). White and bur oak (*Q. alba* and *Q. macrocarpa*), occur on some of the somewhat higher and better drained sites. The poorer drained soils have more pin and swamp white oak, elm, ash, and soft maple, less red and black oak, and no white or bur oak. Similar species compositions occur along the Lake Erie shore in Erie and Huron counties (north-central), and in Marion County (central).

The prehistoric prairie openings of west-central Ohio contain a different sort of oak-hickory association; the soil is better drained and the species are chiefly bur and white oak, and shagbark and bitternut hickory (*H. cordiformis*)

The third type of oak-hickory is a narrow peninsula of chestnut, oak-hickory-chestnut (*Quercus muhlenbergii-Hicoria* spp.-*Castanea dentata*) in eastern Ohio, a region of rather steep hills. Fox squirrels do not seem to use this as readily as the two types previously mentioned.

The most extensive oak-hickory type is being created at the present time and includes a variety of mixtures of oak, hickory, maple, tulip (*Liriodendron tulipifera*), beech (*Fagus grandifolia*), linden (*Tilia americana*), and locally elm and ash. This type includes variations such as oak-hickory, oak-maple, oak-maple-beech, and oak-beech-maple-hickory. Save for the swamp forest and prairie areas, this type occurs throughout the limestone region of western Ohio which was covered by the Late Wisconsin glaciation. Formerly this was a beech-maple climax forest but has reverted, or is reverting, to secondary mixed oak-hickory. The great die-off of beech during the 1932–34 drought has hastened the process, the die-off being especially pronounced in pastured woodlots. In some instances, farmers formerly proud of their wooded acres became discouraged when the beech died and cleared their lands for crops. This practice should be discouraged. As a fox squirrel management measure, these areas should be encouraged to become mixed oak-hickory and beech-maple woods.

The second or beech-maple habitat type, occurs locally on better drained

sites in the swamp forest region of northwestern Ohio and as climax relics or degraded beech-maple woods on the remaining portion of the Late Wisconsin glaciated limestone soils. It predominates on sandstone soils in eastern and northeastern Ohio, and occurs also in extreme southwestern Ohio. In the latter areas the soils are poorly drained and the beech-maple type reproduces itself. There is little or no reversion to a secondary forest type when the original is pastured, cut, or otherwise abused. Within this type there are situations where the soils are so poorly drained that swamp forest species thrive. The beech-maple type varies from nearly pure beech with small amounts of maple on poorly drained soils to beech with a predominance of oak and sugar maple on the better drained sites.

The fox squirrel is the predominant squirrel in the beech-maple woodlots of northeastern Ohio, where the woodlots contain a high percentage of oak. In southwestern Ohio the beech-maple woods have less oak, and a greater variety of tree and shrub species. There the gray squirrel is more plentiful than the fox squirrel, sometimes comprising from 70 to 95 per cent of the total squirrel population. The existence of fox squirrels in most beech-maple woodlots is precarious and unpredictable; in general the population varies directly with the magnitude of the annual beechnut crop.

"The southeastern counties form a dissected plateau, with much of the land in slopes. Here occur forests of oak-hickory, oak-chestnut, and oak-pine, frequently with mixed mesophytic or beech-maple on the north and lower slopes, or in coves. The mixed mesophytic forest is made up of many species about equally numerous, including beech, tulip, maple, magnolia (*Magnolia* sp.), ash, linden, buckeye (*Aesculus* sp.), red and white oak, hickory, chestnut, butternut (*Juglans cinerea*), and sometimes hemlock (*Tsuga canadensis*)." (E. N. Transeau and H. C. Sampson, in Sitterley and Falconer, Ohio State Univ., Dept. Rural Econ., Bull. 108, 1938, p. 19.) There fox squirrels are abundant only in scattered farm woodlands, certain wooded stream bottoms, and on dry ridge tops with considerable white and red oak.

EVALUATION OF HABITAT

Realizing that no balanced management program could be suggested until more was known about the forest conditions of the entire State, a reconnaissance of fox squirrel habitats was made in 1937 to 1939. The survey sampled 41 counties in detail and the remainder superficially; 2,816 woodlots were examined and given ratings as fox squirrel habitat; climax wooded areas rated as ten and young second-growth stands as one. About 600 were rated from the roadside which was easy in western Ohio. The bases for these ratings are given in Table 1; the actual ratings were as follows:

Class	*Number*	*Percentage*
1	490	*18.5*
2	446	*17.8*
3	312	*11.7*
4	316	*12.0*
5	392	*14.7*
6	273	*10.3*
7	169	*6.4*
8	97	*3.7*
9	36	*1.3*
10	20	*0.8*

It was impossible to classify each woodlot exactly in one of the ten groups, and

Table 1.—BASIS FOR RATING FOX SQUIRREL HABITATS IN OHIO.
(excluding extreme southern and southeastern portions)

Factors	Class 1	2	3	4	5	6	7	8	9	10
1	Slash or 2nd growth, canopy 5–20 feet high		Even stand of 2nd growth nut-producing trees		Even stand 2nd growth nut producing trees and associated species, canopy 45–75 feet		Sub-climax or secondary oak-hickory, including beech-maple with 30–40% oak		Climax or near climax oak-hickory or beech-maple woodlots	
2	No acorn-producing trees	Few acorn bearing trees	Canopy 25–35 feet high	Canopy 35–45 feet high	Beech-maple and swamp forest type with at least 40% oak and hickory	Chiefly oak and hickory	Trees average 18″ (15–20″)		Trees average 20″ or more	
3	Solid stands of dying beeches	Almost pure beech-maple	Mostly beech-maple, some oak and hickory	Mostly oak and hickory	Good stand of various aged trees, few old "wolf" trees; canopy height irregular		All larger trees about same age; good reproduction		Good quantity and variety of berry producers along edges and in openings	
4	Barnyard pasture, no oaks	Pasture with less than 20 oaks per acre	Trees average under 10″		Trees from 11–14″ some 4–25″		No pasturing; dense undergrowth	Light pasturing	Canopy 50–75% closed	Canopy over 75% closed
5			One large nut or acorn bearing tree or none	Usually one large nut or acorn tree per acre	2 or more large oaks per acre	3 to 5 large oaks per acre	Canopy less than 50% closed	Canopy over 50% closed	At least 35% of ash, elm, soft maple ("wet" species)	Little elm, ash or soft maple
6			Small groves of trees 1 or 2 acres; like Classes 7 to 10	[1]Small groves of trees 3 or 4 acres; like Classes 7 to 10	Under story largely shrubs and berry patches		Some beech, at least 50% oak and hickory	Oak and hickory predominate		
7				[1]Small barnyard woodlots with corncrib	Herbs and woody undergrowth dense	Pastured				
8					Not more than 30% beech	No beech				
9					[1]Virgin woods 60–75% beech-maple, 10–15% oak-hickory	Even stand 2nd growth chiefly oak-hickory; canopy heights over 70 feet				

[1] Special cases which occur sufficiently often to be considered here.

Winter feeding has relatively little effect in Classes 1 to 4 and moderate effect in Classes 9 and 10, but Classes 5 to 8 can be advanced two to three classes by winter feeding.

some variation is to be expected between the writer's ratings and the actual conditions; many are diverse in composition and others contain only three or four species of trees; some are of even-aged timber and in others it is from 10 to 200 years old; some are dry oak and oak-hickory woods and others are wet beech-maple and swamp forest types.

Most of the data were collected on a county basis but are here assembled for the state, exclusive of the extreme eastern and southeastern portions where fox squirrels are not abundant.

If the ten classes are combined into five, the expected populations of squirrels per 100 acres are more practical and usable:

Woodlot classes	*Percentage*	*Squirrels at height of cycle*	*Squirrels at bottom of cycle*
1+2 poor	*36.7*	0– 15	0
3+4 fair	*24.7*	10– 50	0–10
5+6 average	*26.1*	50–125	10–50
7+8 excellent	*10.4*	160–200	50–90
9+10 good	*2.1*	110–170	40–70

These are potential populations, based upon actual populations determined in study areas representing the five classes and upon which no hunting was allowed. In similar woodlot classes which are hunted, the population is likely to be from 60 to 85 per cent less, depending upon local conditions and hunting pressures.

More than half (61.4%) of the present woodlots are inferior squirrel habitats which will support few if any squirrels in food crises. The climax forest areas are small in total area, and, surprisingly, support fewer squirrels than do the sub-climax or secondary forest types. Two reasons for this are suggested: (1) old trees appear to supply fewer food resources than young trees, and (2) most of the few climax forest areas remaining in Ohio are of the beech-maple type which supply a good mast crop but once in three to five years.

TEMPORARY HABITATS

There are several kinds of fox squirrel habitats capable of supporting squirrels only temporarily because of pasturing, selective cutting, and the occurrence of artificially planted woodlots. A temporary habitat is considered to be a woodlot or group of trees over an acre in size inhabited by squirrels only during certain seasons of the year, or one which can support squirrels in only one year of every three or four.

The first variety of these occurs along streams where the predominant vegetation consists of combinations of elm, ash, soft maple, with associated species such as hackberry (*Celtis occidentalis*), buckeye, and sycamore. Squirrels are more abundant there in spring, when they feed on buds, but usually a few stay throughout summer and autumn, especially if there is a corn field or fence of osage orange (*Toxylon pomiferum*) near by. If a wooded second terrace is present the squirrels may remain throughout the year, as these second terraces usually have tree species combinations of elm, ash, cottonwood (*Populus deltoides*, western Ohio), sycamore, black walnut (*Juglans nigra*), red oak, shagbark hickory, and sometimes white oak. An adequate variety and quantity of these will support squirrels year after year.

Another temporary habitat consists almost exclusively of hickory. These are often the result of clear-cutting and then pasturing a woodlot. Cattle eat the

sprouts of almost every tree species, but especially avoid hickory, resulting in a solid stand of the latter. When these trees begin to produce nuts, squirrels will move in (usually as a result of dispersal movement) and may remain all winter, but are forced to leave the following spring because there is no food available after the nut supply is exhausted.

The third type of temporary habitat is the pure beech or beech-maple woodlot which can supply but one staple food (beechnuts) abundantly and then only during widely separated years.

MOVEMENTS

Fox squirrels do not have the same travel range throughout the year. The search for food, for mates, or for new "homes," results variously in limited or extensive movements.

DAILY MOVEMENTS

The daily movements are varied, yet quite limited. During stormy weather an individual may not move more than 10 or 15 yards from its den, but during warm weather may range over an acre or two. Data were secured by marking and retrapping, and many marked animals repeated five times. In any one woodlot there were not more than four (usually two) trapping periods each year, hence it was almost impossible for many individuals to repeat more than four or five times. In the areas where many squirrels were marked and there was reasonable opportunity for repeats, 21.11 per cent repeated.

The average distance traveled by 129 squirrels which repeated was 136.7 yards; 60 males averaged 154.3 yards, and 69 females averaged 129.7 yards. Thus the females showed an average travel of 24.6 yards less than the males. The frequency and distances traveled between repeats were as follows:

Distance in yards	*Number*	*Percentage*
0 (repeated where tagged)	22	*17.1*
1– 50	9	*7.6*
51–100	20	*15.5*
101–150	26	*20.2*
151–200	18	*13.9*
201–250	15	*11.6*
251–300	8	*6.2*
301–350	3	*2.3*
351–400	5	*3.9*
401–450	2	*1.5*
451–500	1	*0.7*
Total	129	

The daily movements are limited almost entirely to the instincts of food getting and danger evasion. When these are satisfied the squirrels usually retire to "lay-out" limbs, and spend most of the remaining portion of the day sleeping or scratching ticks, lice, and mites. Most of the activity occurs within two or three acres; the area may vary considerably in shape. Generally these squirrels do not go beyond the woodland boundaries unless there is a corn, soybean, or wheat field near by. If such a crop is planted adjacent to a woodlot, the area of the habitat is enlarged by the distance that the squirrels penetrate into the field. This may be 40 to 50 yards in a cut soybean field, but usually not more than 5 to 10 yards in corn or wheat.

The movement of an individual in its "home range" is such that it covers most of the area on an average of once every three days. This behavior was of help when attempting to tag many in a short time; if a trap did not catch a squirrel within three or four days, it was

moved to another site. Also there appears to be a relationship between the size of a woodlot and that of the "home range":

Woodlot	*Acres*	*Average travel, in yards*
"S"	88	163.6
"O"	63	130.6
"K"	41.5	138.1
"F"	39.5	130.7
"J"	26.7	99.4

SEASONAL MOVEMENT

As used here this term refers to the breeding season of the fox squirrel. This movement is believed to be entirely a response to mating instincts. The extent and direction of such movement could not be determined definitely by trapping, and recourse was had to tracking animals in snow or mud and noting individuals in unusual situations. Throughout December and early in January, and again in May, one can note a general unrest in a given squirrel population. What this is and how one can detect it defies description, but an observer can "sense" a difference in the daily behavior of these animals. One then sees a few squirrels along fencerows far from any woodlots. These wandering individuals are more noticeable in winter, when they can be tracked and their rufous color contrasts with the white snow.

The average distances traveled could not be measured, but are thought to be determined by the distances between woodlots, and the number of unmated individuals within a given area. Fragmentary evidence indicates that this movement is largely among the males. The evidence is that (1) the long-time residents in the study areas were females, and (2) one male (No. 394B) was tracked down and collected. The track of the latter was picked up at about 9:30 A.M., January 4, 1938, on the road through the Ohio State Rabbit Farm at Milan, Ohio. It was back-tracked for 0.4 mile and then (starting again at the road) followed along the Huron River for 1.3 miles where it was treed and collected. Many others were tracked from one woodlot to another but the tracks of a particular individual usually became mixed and lost among those of others.

DISPERSAL MOVEMENT

All squirrel habitats tend to become over-populated as a result of reproductive increase. The ultimate result is either a mass die-off, or movement out of the area. The impulse for such movement is usually considered to be *population pressure* or food competition which may or may not be synonymous with *intra-species intolerance*. Regardless of the term used, fox squirrel habitats which are not hunted become overpopulated and each year the surplus moves out.

This movement is sometimes called *migration*, but the term implies departure from and subsequent return to a given area, and is inappropriate here. Neither is the term *emigration* entirely satisfactory; it means literally "to move from," but its present-day meaning implies moving from one point to some other predetermined point, or a mass movement in one general direction, as exemplified by lemmings and gray squirrels. The term *dispersal movement* seems more fitting for the fox squirrel, implying random movements in all directions. In this species the movement is obviously a random one, starting

from one point and extending to some other point unknown and not previously visited by the individual. These movements occur in all directions favorable for travel during the dispersal period.

Evidence of dispersal is conspicuous between August 10 and September 15. The movement in any one year seldom lasts more than two or three weeks, and does not occur at exactly the same time. In some years movement is noticed by many people and reported in newspapers, while in other years it is scarcely observed.

Rural postmen proved to be the best source of information concerning the movements over the entire state, and many of them cooperated with the writer by recording the dates and number of squirrels involved. During this period, especially when squirrels are abundant, they can be found running along fencerows or sitting on posts, and many are reported dead along the road. The writer has seen as many as 14 squirrels per 100 miles driven in one day, but one usually sees only 6 or 8 in the same distance.

The cause of this movement is controversial. The motivating factor is usually considered to be population pressure correlated with a shortage of food, yet it occurs when the food supply is greatest, almost simultaneously with the maturing of the nut crop. The moving squirrels are more noticeable when the population is high, and the writer believes the movement results from *intra-species intolerance*. This view is partially substantiated by the fact that no record of excessive fox squirrel populations, either in the literature or in the field, could be authenticated. Seven such reports were investigated but none showed more than two squirrels per acre.

Two moving squirrels were found dead on the road, in good condition for examination, and three others were collected; all were males, four juvenile males and one adult. It would, however, not be correct to infer that all moving squirrels are males, as this is a very small sample; some females probably are included.

The extent of dispersal was difficult to determine, as reliance was placed upon hunters to report the localities where tagged squirrels were shot. The writer learned that at least 21 such squirrels were shot outside the areas where tagged. Six tags with records were located, and two are of special interest. A male (No. 58641–58642), born in the summer of 1937, was tagged in Woodlot J, 1.7 miles east of Meeker and shot (October 4, 1938 south of DeCliff, Ohio, a "straight-line" distance of eight miles. Another male, (No. 59313–59314) of the same woodlot was tagged on July 5, 1938, retaken in the same trap on July 9, and shot 104 days later 6 miles southeast of Kenton, Ohio, in this instance about 14 miles away. These probably should be considered as unusual records until more are received; the four other squirrels traveled 0.4, 1.2, 1.5, and 1.5 miles, respectively. Some of these movements may have resulted from mating instinct rather than dispersal, but both types are forms of dispersal.

There was no evidence in this study of any mass movements involving thousands of individuals as recorded of gray squirrels (*Sciurus c. carolinensis*) in the early history of Ohio. There are no references to movement of this sort for fox squirrels in the literature.

A. Area "M," an extreme instance of over-pasturing. *B*. Example of excellent fox squirrel habitat, Darke County, Ohio. *C*. Typical leaf nest of fox squirrel.

TE 11

leaf nest of fox squirrel.

LEAF NESTS

Nests of leaves are placed in the crotches of limbs or on tops of the main trunks of trees (Pl. 11, *C*). One can usually find squirrels where these nests are present. The nests are used as escape cover throughout the year, and to bear and rear young during the breeding season.

Squirrels which habitually use tree dens will often build some sort of nest but may or may not use it. Where not used or kept in repair, wind, rain and snow rapidly break down the structures and they soon disappear. Nine nests under observation were blown down in less than thirty days after construction.

SUMMER NESTS

Squirrels almost always build one nest each year and often two. If a second is not built, the squirrel usually has a tree den or repairs its first nest. Nest building starts soon after the leaves are on the trees in May and June, the earliest record being May 16. A leaf nest can be constructed in less than 12 hours and is usually completed within two days. It was difficult, therefore, to locate many nests while under construction but 29 early nests were found in 1937–40 as follows:

	Nests		*Nests*
May 16	3	June 7	1
18	1	8	3
20	4	9	1
24	2	13	3
29	3	16	1
30	3	23	1
		24	2
		28	1

WINTER NESTS

There is little building during July and August, although some new nests can be found during every month of summer and autumn. By autumn early nests may become so disintegrated as to be no longer usable; they are abandoned and new nests are constructed before all leaves are off the trees. Early nests built on crow nests or other solid platforms, are usually in good repair by autumn and frequently are repaired for winter use. They are readily identified by containing both new and old leaves. Repairs are made at almost any time in the winter.

The dates for construction of late or winter nests were difficult to determine, because less time was available for observing them. The dates for 62 such nests, possibly including rebuilt early nests, were as follows:

Aug. 11 (late summer?)	1
Sept. 10	2
11	1
Oct. 10–23	54
Nov. 3	2
4	2

The data of this investigation indicate no essential difference in size or construction between early and late nests. Both are fundamentally a pile of leaves shaped more by use than by construction. Repaired nests may appear to consist of layers, but more as a result of accident than design. No significant difference was found between the size of early and late nests. Seton, (Lives of game animals, 1928, 4: 93) notes two kinds of nests, one loosely built about 20 feet above ground, and another heavier, more carefully built, and placed higher in the tree. The writer noted this difference in both early and late nests. Only adult females (11 with young) were found in the higher, well-built, and compact nests. The other type appeared to be used exclusively by males and immature females. No young

squirrels or pregnant females were found in the lower nests.

The durability of a nest depends largely upon its location and amount of use. An unused nest soon collapses and breaks up. The average used nest lasts for six to ten months, and longer if on a solid support or in a greenbrier or grape vine.

In addition to these two types of nests, piles of leaves are found in crotches of trees scattered through the woods. Some approximate the size of nests but have no cavity. They have been variously interpreted as: (1) nests abandoned before completion, or the work of juveniles; (2) nests built by traveling squirrels temporarily concentrated along the borders of a corn field (3 known instances); and (3) evidences of a delayed or pseudo-nest building urge. The piles of leaves are sometimes used as hiding places, but most of the fox squirrels observed preferred to lie lengthwise on a large limb.

NEST MEASUREMENTS

A total of 306 leaf nests in 22 species of trees were examined in detail and data for some of these are presented below. More than half of the studies on leaf nests were made in oak-hickory woodlots, hence a higher percentage of nests were found in oak trees.

Measurements of 62 nests are summarized in Table 2. The data show no essential difference between early and late nests. It was difficult to work with the nests without altering their shape and size and the measurements are approximate, especially for nest cavities.

Tree	*Number*	*Percentage*
Pin Oak	87	*28.3*
Red Oak	55	*17.9*
Black Oak	32	*10.4*
Swamp White Oak	31	*10.1*
White Oak	25	*8.1*
Beech	22	*7.2*
Elm	16	*5.2*
Red Maple	13	*4.2*
Cottonwood	6	*2.0*
Bur Oak	3	*1.0*
Hickory	3	*1.0*
Sugar Maple	2	*.6*
Chestnut Oak	2	*.6*
Sassafras	2	*.6*
Scarlet Oak	1	*.3*
Wild Black Cherry	1	*.3*
Sour Gum	1	*.3*
Linden	1	*.3*
Sycamore	1	*.3*
Black Walnut	1	*.3*
Black Locust	1	*.3*

Most of the nests were constructed entirely of leaves. One contained rags, two a few corn husks, and one was lined with sedge grass. The leaves are usually taken from the nest tree. A damaged nest may be repaired with leaves from the same tree, or with an assortment of leaves gathered from the forest floor.

In gathering materials for a nest the squirrel cuts twigs 6 to 12 inches long which bear many leaves and these twigs are piled up in an orderly manner to form the nest.

Table 2.—MEASUREMENTS OF FOX SQUIRREL NESTS IN OHIO.
(*Dimensions in inches except height above ground*)

	Summer nests (14)		*Winter nests (48)*	
	Average	*Extremes*	*Average*	*Extremes*
Height above ground, feet	41.3	28–70	40.5	25–65
Diameter of nest tree	15.8	8–26	16.2	6.5–32
Horizontal diameter of nest	12.6–16.7	8×11 to 18×20	12.2×14.9	8×9 to 17×21
Vertical height of nest	12.0	8–20	11.9	8–23
Inside diameter of nest	4.6×5.5	4×4 to 6×6	5.3×5.6	4×4 to 8.5×10
Inside height of nest	4.7	3.5-6.0	5.6	3.5-9.5

MANAGEMENT OF DEER AND CATTLE ON THE ARANSAS NATIONAL WILDLIFE REFUGE, TEXAS[1]

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Introduction

The Aransas National Wildlife Refuge, consisting of 47,325 acres, is located near Austwell on the Black Jack Peninsula. The presence of many deer there has resulted from almost total protection from hunting and some reintroduction during a period of 16 years. Previously there was only a small remnant of the original population. Problems are arising from the presence of cattle, but they have not reached the critical stage of similar dual-use areas of concern on some western ranges.

History of Deer Population.—A good many deer occupied this sparsely populated region until about the middle of the nineteenth century. Allen (1894) quotes a Captain Bailey who said that thousands of deer died here from "blacktongue" in 1857 or 1858. Deer were rare on the peninsula in the early nineties but were "quite numerous on Saint Joseph Island, where they are protected by Messrs. Wood and Allyn, who own the island and use it as a cattle and sheep ranch" (Allen, 1894). The northern part of Saint Joseph Island lies less than two miles off the southeastern part of the Black Jack Peninsula, separated by the shallow waters of San Antonio Bay. Possibly, as deer were removed from the mainland, others emigrated to the peninsula from the nearby protected islands.

Between 1913 and 1928, deer were not plentiful in the area, although by careful hunting one could secure venison at any time. The local residents did not utilize deer to any extent as the meat of domestic cattle and hogs was better. This fact may have been a contributing factor in the survival of deer in the relatively small but brushy areas in this region.

In 1919 Leroy G. Denman of the San Antonio Loan and Trust Company took over the management of the ranch on Black Jack Peninsula. He reported few deer and many hunters between 1919 and 1924. In 1924, a seven foot wire fence with locked gates was installed, and every effort was made to keep out hunters. Denman then introduced deer into the area as follows:

1925–1926: Five or six "Texas deer," caught by friends of Mr. Denman.

1933: Twenty-six deer caught in southern Texas, shipped to the Kansas City Zoo, and then sold by the zoo to Mr. Denman.

1935: One "Virginia white-tailed buck" from Georgia.

In addition, Mr. Denman states that between 1927 and 1937 from 8 to 12 pet deer, caught as fawns by friends, were released on the ranch. Fifty mule deer from Colorado and numerous fallow deer from England were also introduced with slight success.

This brief history of the herd can be

[1] J. O. Stevenson, W. P. Taylor, U. S. Fish and Wildlife Service, and W. B. Davis, Department of Fish and Game, Texas A. and M. College, and others aided in the preparation of this paper.

summed up as follows: A hardy native remnant was supplemented by white-tailed deer from the southern United States, including at least two subspecies. In addition, exotic species were introduced with little success. Under protection from man, the herd multiplied to an estimated 4,000 by 1937. The cruise counts of 1939–40 indicated 3,800 white-tailed deer and 5 fallow deer.

Species of deer.—The deer could be a mixture of several races of the white-tailed deer (*Odocoileus virginianus*), but this survey suggests that the original native stock probably survived as the dominant strain. During the fall and winter the deer normally have a "salt and pepper" pelage, darker or "bluer" than the reddish summer coat. During early summer some individuals show a distinct "blue" cast; others are "red." Different individuals may molt at different times, according to the condition of each. An explanation deserving further consideration has been mentioned by E. A. Goldman of the U. S. Fish and Wildlife Service, who examined two skulls with hides from the refuge. In a letter to former Refuge Manager James O. Stevenson, in August, 1940, he states that the hide was intermediate between *texanus* of southern Texas and *mcilhennyi* of western Louisiana and the nearby coastal areas. He tentatively assigned the specimen to *texanus*, however, pending examination of more local specimens. A distinctly "blue" specimen secured August 23, 1940, also intermediate, was tentatively assigned to *mcilhennyi* by Goldman. His suggestion that the deer are intergrades seems to be valid as the refuge is located about midway, ecologically speaking, between the ranges of the two subspecies.

Early ranching on the area.—The early history of ranching on the St. Charles Peninsula is fragmentary. By the 1890's several ranchmen had taken over parts and were running small acreages as individual units. Oliver Brundrett, now of Rockport, for instance, had 1,200 acres in the southwestern part of the area on which he grazed up to 300 head of cattle between the years 1913 and 1938. A Mr. Smith, now of Rockport, ran hogs in the vicinity of Miele Dietrich Point at the turn of the nineteenth century. During this time, Cyrus Lucas ran cattle over the major part of the peninsula. According to Mr. Smith, burning of both oak brush and spartina grass was a common practice.

As stated above, when Mr. Denman took over control of the ranch in 1919, winter burning was practiced wherever practicable between then and 1935, but not thereafter. Since the area became a federal migratory waterfowl refuge in November, 1937, there has been no burning of oak brush. The average number of cattle on the tract between 1919 and 1938 was 5,900. Hogs were also allowed to run there.

Vegetation.—The refuge supports a great variety of plants, including representatives of both eastern and western floras. For this study three ecologic types are recognized: oak brush, sacahuista grass, and salt marsh.

The oak brush type covers about 35,758 acres, over 75 per cent of the area. The dominant plant is the live oak (*Quercus virginiana*), of two forms, tree and shrub, or shinnery. The trees are in small groves or "mottes," from a fraction of an acre to several acres in extent. The shrub form is a few inches to about seven feet in height and is one of the most aggressive local plants. Burning

favors the shrub form at the expense of the trees. After burning, oak brush grows abundantly and forms impenetrable thickets if undisturbed. The myrtleleaf oak (*Q. myrtifolia*) is another common species of shinnery form.

The area was named for the abundance of another small species, the blackjack oak (*Q. marilandica*). This is large-leafed and grows in scattered stands on the drier inland parts of the area. It is an important deer food and much of it shows a browse line about 57 inches above the ground. Only one other tree on the area, the prickly ash (*Xanthoxylum clava-herculis*), shows such heavy use so plainly. Sweet bay (*Persea borbonia*) dominates the brush in certain areas, particularly in the north-central part of the refuge. The brush is not of especial food value for deer, but provides cover. From the deer-cattle standpoint, the most important grasses in the oak brush areas are little-bluestem (*Andropogon scoparius*), three species of *Paspalum*, Bermuda (*Cynodon dactylon*), and bur grass (*Cenchrus incertus*). In parts of the refuge, little-bluestem dominates the shinnery form of oak brush. These interior grasslands are dotted with small mottes of live oaks.

The sacahuista grass type is best developed in the northwestern part of the refuge. The dominant is the large, coarse sacahuista or needle cordgrass (*Spartina spartinae*). Thick clumps have blades averaging 2½ feet long, which bend over, shade the ground, and effectively crowd out competing plants. When of this size, they are not attractive as food to deer or cattle. If not burned it comprises between 80 and 90 per cent of the stand, but after burning the new shoots are most enticing to deer and other herbivores. Preliminary studies indicate that frequent burning in late fall or winter opens the stand, provides succulent food, and allows other plants, such as *Croton*, *Lithospermum*, and *Panicum*, to come in. Cattlemen have burned these "sacahuista flats" for many years, but more study is needed to put the practice on a sound, scientific basis.

The salt marsh type lines the shores of the peninsula. The dominants are pickleweed (*Salicornia*), salt grass (*Distichlis spicata*), and mud salt grass (*Monanthochloe littoralis*). A sub-type in the northeastern part of the refuge is quite different. Instead of being flat and damp, it is made up of two shell ridges running parallel to the shore, on which grow many plants typical of the brushy areas of southwestern Texas, including Spanish persimmon (*Diospyros texana*) and mesquite (*Prosopis chilensis*). Deer use these ridges both for browsing and cover. The salt marsh type is important since both deer and cattle use these tidal and near-tidal flats in hot weather. The resultant trampling makes these areas critical in deer-cattle management plans.

Vegetation of the early days.—A record of the vegetation of the nineteenth century gives better understanding of the present ecology of the area. Allen (1894: 167), quoting H. P. Attwater, gives a fairly clear picture of the vegetation of this region in his paper on the mammals of Aransas County. He states:

> "The prevailing tree growth on the peninsulas consists of dwarfed live oaks, 'sweet bay' (*Persea carolinensis*), and 'huckleberry' (*Vaccinium arboreum*), with scattered groups of anaqua (*Eluetia elliptica*), hackberry, mezquit, and prickly ash. The shell ridges along the shores and on St. Joseph and the smaller islands are covered with a tangled

growth of 'chaparral,' consisting chiefly of dwarfed persimmons, huisache and 'cat-claw,' with patches of dewberry vines and occasional bunches of prickly pear (*Opuntia*). On St. Charles Peninsula is a considerable area of black-jack oaks.

"Along the shores is a belt of comparatively open country, of an average breadth of half a mile, covered with a dense growth of weedy plants, the most common being 'wild sage' (*Croton texensis*), *Eupatorium*, *Cassia*, *Baptisia*, *Helenium*, and *Amphiachyris*. On the salt flats *Statice* and *Lycium* grow in abundance. The most common grasses on the uplands are Bermuda and burgrass (*Cenchrus tribuloides*)."

Men who have lived in this country for forty years or more are almost unanimous in stating that there is much more brush now than formerly. Recent burns (1937 and 1940) on the Aransas Refuge in the brush type indicate that live oak brush and sweet bay are quickly dominating the stand. Local cattlemen state that burning has to be kept up continually or the brush will dominate.

The actual composition of the early vegetation is difficult to determine accurately, but, as Rhoads (1893) and F. E. Clements have indicated, the following general picture of the history of the vegetation is probably fairly close to actual conditions.

The coastal prairies, before the time of white men, were dominated by grasslands. When cattle were introduced in large numbers the grasses were heavily grazed. This gave the oak brush a chance to grow and spread, which it did. The domination of oak brush probably results because the cattle keep normally dominant grasses suppressed. Burning, therefore, followed by heavy grazing, allows the brush to return. If the area were burned and not grazed or burned and grazed only lightly, the grasses probably would again dominate. If, upon experiment, this proves to be true, it will demonstrate that the original vegetation, before the time of the white man and his cattle, was an undisturbed climax of grasses.

CENSUS METHODS

Censusing of deer on the refuge is difficult. The low relief, heavy underbrush, and mild weather with little or no snow, effectively eliminate the more common methods of counting deer such as on watersheds (Nielson, 1938) or in yards during winter concentrations in the snow country. A modified form of the cruise or strip method (Ruff, 1939) was used, with the drive method (Gross, 1936) as a check. Daily counts were made from an automobile over a given route to ascertain a feasible index method. The peculiar conditions of protection from hunting and a semi-tame population of deer make the problem somewhat unique and therefore not entirely applicable to all areas. The presence of a high fence across the north end of the area and the location of the refuge on a peninsula tend to stabilize the population. Deer have been seen outside this fence, however, and are also known to swim the adjacent bays to nearby wooded peninsulas and islands.

An attempt was made to correlate deer seen with cattle seen, a method used by Taylor (*MS*, 1926) in his study of mule deer on the Grand Canyon National Game Preserve, but the constant shifting of cattle from pasture to pasture by the grazing permittee on the refuge ruled out this method.

The phenomenal growth of the deer population to between 3,000 and 4,000 since nearly complete protection was

afforded in 1924 indicates the need for some knowledge of future population trends. This high population does not constitute an emergency, but the possibility that further increase may tend to upset herd and range conditions is a real one. Any method of census that will yield valid comparative figures from year to year at a reasonable cost will indicate a trend that may be checked before conditions reach the serious stage of the well-publicized winter deer concentrations of the Rocky Mountain states.

Cruise method.—Several workers, particularly in the Federal services, have in recent years been working on different forms of "cruise" or "strip" methods for counting deer. With variations, these can be traced to standard methods of cruising timber, wherein predetermined acreages are tallied to give a certain percentage of the whole and the result multiplied to include the total acreage. The Aransas Refuge presented a problem that conceivably would be adaptable to this type of coverage, so a cruise survey was undertaken.

The edges of the refuge on the three sides bounded by water are, generally speaking, open prairie, spartine meadow, or salt flats, comprising about 11,567 acres. The remainder is broken forest dominated by live and black jack oaks with an under story of grasses and herbs.

After feeding in the morning, the deer retire to this central brush area and remain there until afternoon. It seemed desirable to make counts when they were distributed in the forest and comparatively quiet, as the seldom-used sand roads afforded access to all of the forest. All major fence lines and most of the seldom-traveled roads were covered on foot, the mileage being determined by pacing from a detailed map (4 inches per mile). As deer concentration occurs at the wells, care was exercised in taking counts between the wells so the tally would be conservative. More than 30 miles of strip was cruised representing 1,265 acres or 4 per cent of the 33,165 acres of "oak brush" central forest. The flushing distance was found by trial to average two chains to a side, so all foot-strip counts in this type were calculated on a four-chain strip basis.

The interior northern prairie of 2,593 acres, although surrounded by forest, was figured separately, because the population in open country was different from that in the surrounding oak brush. The flushing distance in the latter proved to be essentially the same as in the oak brush, because of the frequency of small mottes. This may be partially accounted for by the fact that the semi-tame deer of the refuge are more used to seeing people in cars or afoot in the open prairie than in the heavy brush.

The total oak brush acreage was divided by the acres covered in the strip-cruises in that type and multiplied by the number of deer seen. The same was done for the smaller inland paririe type. The sum of these two figures indicated 3,740 deer for the 36,758 acres. This acreage constitutes, roughly, the center of the refuge where the deer may be found between 9 A.M. and 1 P.M. in January.

The strips were cruised against or across the wind in all types of weather, which is never severe, by one or two observers between 9 A.M. and 12:30 P.M.

Drives.—Four successful winter drives

were made with CCC labor, three in selected typical areas of oak brush. For each a line of beaters advanced from a fence to the opposite end of the area. The fenced sides and end zone were covered by responsible CCC boys and their leaders. The fourth drive, over a triangular area of 668 acres in the 2,593-acre central park, was conducted as suggested by Gross (1936). The total population was indicated as 3,127 deer.

The drives were made between 9 A.M. and 2 P.M. when the deer were in the oak brush. The writer believes that careful cruises by a trained observer are more feasible than drives, because of the high cost of the latter method.

Random auto counts.—Driving over the refuge in the afternoons between 1:30 P.M. and dusk, one is impressed by the many deer seen feeding in the swales, spartina flats, salt flats, and prairies. They are not seriously disturbed by approaching cars and those close to roads move away slightly with apparent unconcern. Seven afternoon trips totaling 147.5 miles were made at random in all types of weather. With a calculated average visibility of four chains on each side, this represented 10,184 acres or 21.5 per cent of the refuge; the 903 deer seen implied a total of 4,190 deer.

Discussion.—The results of these three methods are not exact. The drive appears to be least useful because of the cost and manpower needed. The auto count, which can be done in connection with other business, and the cruise count show possibilities of securing good comparative counts. The counts can be recorded by months for each year, and with improvements from further experience would indicate any population trend seriously affecting the life of the herd or the condition of the dual-use range. For auto counts a series of regular trips should be made the same from year to year. If the auto counts should indicate an undesirable change taking place, strip counts on foot or on horseback could be instituted to study the trend more carefully. The random auto count, however, must be applied with caution as many factors probably influence the number of deer seen, one of which is known to be weather conditions. Records of these counts should be made for at least four or five years. By comparison with a similar cruise record, a correlation might be evident.

Index count by auto.—Auto counts were made evening and morning, over a fixed 8-mile route during late December, January, and a few days in March. The January data are most complete.

The morning trips were started generally about 7 A.M. at a time when visibility was satisfactory. All the deer seen were counted, but no attempt was made to distinguish sexes as bucks began to lose their antlers in early January. The car was driven at an average speed of 15 miles an hour with the driver making the observations. There was practically no traffic on the road in the mornings and only an occasional car on the evening run. Temperature at the time of starting, direction and velocity of wind, and percentage of overcast were recorded for each trip.

The morning counts showed a close correlation between the temperature and the number of deer seen (Fig. 1); discrepancies probably are due to such variables as the percentage of overcast and the velocity and direction of the wind. With an average morning temperature of 42°F., an average of 11.6

deer were seen. On the 8 days when 20 to 37 deer were seen the temperature was 44 to 58°F., the sky partially overcast, and there was little or no wind.

The evening counts, starting at approximately 5:45 P.M., showed a consistently higher mean, 39+°F., for the month. The temperature correlation (Fig. 1) was not so close, yet indicates that more deer were seen on evenings of higher temperature. On 9 days when 50 or more deer were seen the temperature was moderate, 44 to 73°F., the sky partly overcast, and there was little or no wind.

These field data suggest that during January at this location a comparative index of population can be obtained over a period of years by correlating the temperature and the number of deer seen on this route. This index count can be made in 20 minutes. There is now a weather bureau station on the refuge so that the daily weather can be noted as a matter of routine. An appreciable rise or decrease in number of deer from average yearly index counts, say of 25 days' duration in January, would indicate a total population change. The cost of index counting is low.

Sex ratio count.—This was made when it was easy to differentiate does, bucks, and fawns. Many of the fawns were so small that they lay hidden, and the fawn count is not considered representative. September is suggested as the best time for this type of count. Six trips were made from July 24 to August 16 by automobile over predetermined routes between 5:30 and 7:30 P.M. No roads were traversed twice. The total was 221 bucks to 240 does suggesting that the present herd is close to normal, with a sex ratio of 92.5 to 100.

DEER-CATTLE RELATIONSHIPS

Food of deer.—Perusal of the literature revealed little of a definite nature on the food of Texas deer. The stomachs of several specimens were sent to the Fish and Wildlife Service for examination. That of a doe accidentally killed January 24, 1940, contained the following: leaves of *Quercus* (some *virginiana*, mostly *marilandica*), 76 per cent; leaves of *Ilex vomitoria*, 23 per cent; grass blades, 1 per cent.

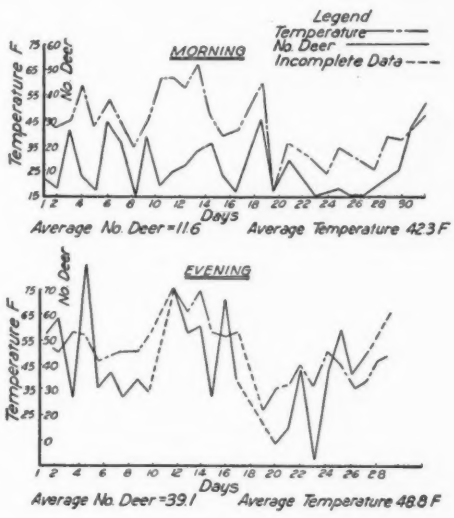

Fig. 1. Correlation of temperature and deer observed on the Aransas National Wildlife Refuge, January, 1940.

Table 1 summarizes the qualitative data available from stomach analyses and observations by the refuge personnel and the writer. Admittedly it is an incomplete record. The list includes 39 plants recorded by watching deer during July and August, the principal months of our field observations on food.

The observer stationed himself before

daylight on a lookout tower, or windmill, or in a tall tree. As it became light enough to see, groups of deer nearby were watched carefully, some within a hundred yards and some within a few feet. The observer recorded their normal feeding habits without the animals being aware of his presence. Eight- or ten-power glasses were used to note details. The data were recorded as "deer minutes," as done by Dixon (1934) in his study of deer in Yosemite National Park. Deer minutes as used here means the time a deer spends in feeding, multiplied by the number of deer under observation. The number of deer minutes that a group spent in each plant association was ascertained by "spotting" certain plants; then as the deer moved on, the observer went over representative parts of the area just vacated to observe and collect the plants eaten. Sometimes it was possible to secure the percentage of time spent on various

Table 1.—CALENDAR OF DEER FOOD.

January-February

Thuja sp.
Andropogon scoparius
Cynodon dactylon
Distichlis spicata
Spartina spartinae
Liliaceae
Myrica cerifera
Quercus marilandica
Quercus virginiana
Celtis pallida
Urtica sp.
Ilex vomitoria
Lantana sp.

March-April

Quercus virginiana
Prosopis chilensis
Xanthoxylum clava-herculis
Vitis candicans
Lantana sp.

May-June

Vitis candicans

July-August

Andropogon scoparius
Cenchrus incertus
Cynodon dactylon
Dactyloctenium aegyptium
Distichlis spicata
Manisurus sp.
Paspalum sp.
Spartina spartinae
Axonopus compressus
Cyperus articulatus
Myrica cerifera
Quercus myrtifolia
Quercus marilandica
Quercus virginiana
Boerhaavia caribaea
Persea borbonia
Prosopis chilensis
Xanthoxylum clava-herculis
Croton glandulosus
Croton punctatus
Croton texensis
Croton sp.
Stillingia sylvatica
Rhamnus sp.
Vitis candicans
(Vaccinium) Batodendron arboreum
Diospyros texana
Lithospermum sp.
Callicarpa americana
Lycium berlandieri
Solanum rostratum
Stemodia lanata
Cephalanthus occidentalis
Diodia teres
Gutierrezia texana
Parthenium lyratum
Xanthium sp.
Neptunia sp.
Physalis sp.

September-October

Andropogon scoparius
Distichlis spicata
Manisuris sp.
Paspalum sp.
Axonopus compressus
Quercus virginiana (acorns)
Richardia scabra
Iva augustifolia
Iva ciliata
Polypteris callosa
Callicarpa americana
Bacopa sp.
Stemodia lanata

November-December

Thuja sp.
Liliaceae
Celtis pallida

species. If a group of deer did not happen to be close enough to a vantage point for satisfactory observation, it was approached on foot or in an automobile for more accurate observation at short range.

In a second system of recording, each observation was considered as a unit, whether for one minute or more than an hour and involving one or ten deer. The plants eaten during one observation were listed and credited as one observation. The results for August, 1940 (Table 2), show that during the early morning and evening feeding periods the deer preferred grasses in 52 per cent of the observations. The 8,489 deer minutes recorded in August (Table 3) indicate that 6,181 minutes or 72.8 per cent were spent eating grass. The observation system does not coincide with the deer-minutes system because of the large relative weight for numerous plants merely nibbled. The deer-minute system affords a more accurate record of relative values. Starting about August 20, it was noted that the deer began to browse the leaves and acorns of live and myrtleleaf oaks. Pierce Uzzell, while working on the Aransas Refuge in

Table 2.—NUMBER OF OBSERVATIONS OF DEER FOOD PER PLANT, AUGUST, 1940.

	Non-grasses	*Grasses*
Paspalum sp.		10
Cynodon dactylon		10
Andropogon scoparius		9
Quercus myrtifolia	8	
Spartina spartinae		4
Cenchrus incertus		4
Xanthoxylum clava-herculis	4	
Spartina patens		3
Diodia teres	3	
Unidentified grasses		3
Stillingia sylvatica	2	
Persea borbonia	2	
Gutierrezia texana	2	
Quercus virginiana	2	
Quercus marilandica	2	
Cassia fasciculata	2	
Cyperus articulatus	2	
Monanthochloe littoralis		1
Dactyloctenium aegyptium		1
Distichlis spicata		1
Panicum sp.		1
Chloris sp.		1
Xanthium sp.	1	
Physalis sp.	1	
Erigeron repens	1	
Callicarpa americana	1	
Rhamnus sp.	1	
Stemodia lanata	1	
Batodendron arboreum	1	
Lithospermum sp.	1	
Lycium berlandieri	1	
Croton sp.	1	
Solanum rostratum	1	
Croton glandulosus	1	
Parthenium lyratum	1	
Boerhaavia caribaea	1	
Prosopis chilensis	1	
Total Observations	44	48
Percentage	*48*	*52*

Table 3.—DEER FOOD, ARANSAS NATIONAL REFUGE, AUGUST, 1940.

	No. of Deer Minutes	*No. of Observations*	*Per cent*
GRASSES			*72.8*
Paspalum (3 species)	2,113	10	
Andropogon scoparius	979	9	
Cynodon dactylon	759	10	
Unidentified grasses	594	3	
Chloris sp.	565	2	
Spartina spartinae	417	4	
Distichlis spicata	368	1	
Cenchrus incertus	233	4	
Spartina patens	101	3	
Panicum sp.	22	1	
Dactyloctenium aegypticum	15	1	
Monanthochloe littoralis	15	1	
Subtotal	6,181		
SEDGES			*6.1*
Cyperus articulatus	513	2	
TREES			*9.2*
Quercus myrtifolia	482	8	
Quercus marilandica	202	2	
Xanthoxylum clava-herculis	93	3	
Quercus virginiana	6	2	
Prosopis chilensis	1	1	
Subtotal	784		
SHRUBS AND HERBS			*11.9*
Diodia teres	331	3	
Lithospermum sp.	240	1	
Misc. unidentified	95	3	
Persea borbonia	72	2	
Stillingia sylvatica	49	2	
Gutierrezia texana	42	2	
Croton sp.	40	1	
Erigeron repens	32	1	
Callicarpa americana	30	1	
Cassia fasciculatus	23	2	
Croton glandulosa	21	1	
Boerhaavia caribaea	15	1	
Parthenium lyratum	10	1	
Solanum rostratum	9	1	
Physalis sp.	1	1	
Xanthium sp.	1	1	
Subtotal	1,011		
Total Deer Minutes	8,489		

1939, independently noted this change from grass and herbs to browse in late August and early September. He also found deer utilizing about 60 per cent of grapes in the mottes of live oak in the northern part of the refuge.

More study is needed to determine the value of direct observation, as by checking with stomach analyses. At some future time it may be necessary to study in detail the food eaten by cattle, but at present food does not appear to be a limiting factor for either deer or cattle, as to quantity. The browse lines on *Quercus marilandica* and *Xanthoxylum clava-herculis*, and the apparent advantage of feeding cottonseed cake to cattle during the winter, however, are indications that the quality of food may not be ideal.

Cattle food.—During the winters of 1939 and 1940, the owners of the cattle fed cottonseed cake. Typical, heavily utilized areas in the interior of the refuge show heavy use of *Andropogon scoparius* and other grasses in the association, such as *Chloris* and *Paspalum*. During December and January, cattle frequently browse on live oak brush and in late March they feed on its new foliage. During the winter, any grass or herb that shows new growth is eagerly sought by both cattle and deer.

Bone meal has been provided at the various windmills and, according to the ranch foreman, the use of this feed by the cattle is increasing. The heavily used "beaches" or salt flats produce much feed; *Salicornia*, *Samolus*, and *Spartina alterniflora* seem to be preferred. An observational plot on the eastern shore near Mustang Lake showed the following composition in a heavily grazed place: *Distichlis* (4 inches high) 90 per cent; *Salicornia*, 10 per cent. Across a slough, where grazing was less, the composition was *Distichlis* (to 10 inches high), 70 per cent; *Salicornia*, 20 per cent; *Samolus* and other marsh plants, 10 per cent. Former Refuge Manager Stevenson has noted the cattle in the shallow bays feeding on *Ruppia maritima* to some extent.

Notes for July and August indicate that the cattle then forage mostly on grasses, including *Andropogon scoparius*, *Dactyloctenium*, *Cynodon dactylon*, *Cenchrus incertus*, *Spartina alterniflora*, *Spartina patens*, and *Spartina spartinae*; *Carex*, *Juncus*, and various forbs are taken if low and succulent. No browsing by cattle was noted in July and August.

Seasonal habits and daily movements of deer and cattle.—From December through March, the daily routines of both deer and cattle were studied. By 7:15 A.M., when light enough to observe, the deer had left the oak brush where they had bedded down. Those near the bay shore started feeding out onto the *Salicornia* flats, picking at bushes and herbs on the way. Those in the interior started to feed along borders of the openings and slowly worked into the centers of these glades. By 9:00 A.M., the deer were again largely in the brush, feeding or resting, whereas the cattle were beginning to appear from the brush and worked leisurely toward the open beaches or vicinity of the mills where they waited to be fed cottonseed meal. Through the middle of the day the cattle were seen in all the openings munching on grass and oak brush.

By 1:30 P.M., the deer began to emerge from the oak brush and by 6:00 P.M., most of the cattle had bedded down in the brush. From 5:30 P.M. until

dark, the deer fed close to the brush, but kept away from the open marsh lands except on the edges. During January, when morning and evening counts were being made, two or three times as many deer were seen in the evening, on a monthly average, as in the morning.

Deer herding occurs on the open grass-covered prairies of the refuge during the winter, reaching a peak in late February and early March. As many as 150 deer have been seen from one point, feeding in the late afternoon on the sacahuista flats and the drier salt marshes. When disturbed by the approach of a car, they invariably sought the oak brush cover.

During July and August both the deer and the cattle have a daily routine slightly different from that of the winter. Deer fed commonly at all times of night. By 7:00 A.M. most of them were out of sight, feeding or resting under cover of the oak brush. They are not frequently seen at water, but one group of fawns, does, and bucks was seen watering at 7:00 A.M. In mid-afternoon, they were in the more open places and the number seen increased toward sunset. In late August there was some tendency to form herds. There were mixed groups numbering up to ten, and one group of 25 bucks was on the sacahuista flats near the ranch house.

Few cattle were seen before 7:00 A.M., when they began to appear in groups, filing to the water tanks and usually drinking at once. This routine generally continued until about 10:00 A.M. when 60 or 70 would be around a tank. Active feeding started at dusk and continued late into the night. During the warmer days of summer cattle often stand 50 yards from shore in the shallow waters of the bays or in the water of the overflow ponds to obtain relief from flies and mosquitoes.

LIFE HISTORY NOTES ON DEER

Refuge records for 1939–40 afford the following information: (1) The rutting season extends from about October 15 to December 15; fawns are dropped in May and June, and one a few hours old was noted on April 28, 1940. (2) The nubs in the velvet can be observed on some bucks by the last week in March; the velvet is still present on some antlers in early September; bucks began dropping their antlers by the end of December and early January, mostly between January 10 and February 10. (3) The adequate cover and food supply evidently have contributed to the freedom of the deer from disease. During the summer of 1940, 5 to 10 dead deer were reported each month by the personnel on the refuge. As soon as an animal dies, it is immediately set upon by vultures (both black and turkey), so that only an occasional carcass can be examined. A dozen ticks, found on the antlers of one deer, were sent to Dr. H. Schmidt of the Agricultural and Mechanical College of Texas, who identified them as the common gulf coast tick (*Amblyomma maculatum*). A doe accidentally killed the winter of 1940, and a specimen secured the following summer, were both fat and in good condition.

MANAGEMENT

The management of the immediate past has not produced any permanent damage to the range, but some local overgrazed areas need attention. The present situation appears to call for some redistribution of the livestock.

The remedies are simple and meet the approval of the local people concerned.

Water is a primary factor in the year round distribution of cattle. If windmills are properly placed and water flows constantly, the cattle will be scattered out. Some additional wells are needed to insure filling the concrete water tanks at each millsite and supply the supplementary overflow ponds. The ponds are of primary importance to wildlife, yet many of them dry up during dry seasons. This inhibits the growth of succulent feed on their margins, and destroys feeding and resting grounds for shore birds and geese. Deer prefer to water at overflow ponds rather than at concrete tanks. Having a more constant water supply at these overflow ponds, therefore, will benefit both wildlife and cattle. Even if the overflow ponds are fenced, the succulent feed growing along the margins of the outlet will be used by domestic stock. Three of these double wells are now in use, proving most satisfactory.

In this brushy country, cattle will not make daily trips of more than a mile for water; therefore, any area more than a mile from fresh water will not be used. With non-utilization, live oak brush quickly becomes impenetrable in some places and grows to a height of seven feet or more within a few years. These areas of heavy brush are not preferred by the deer as feeding grounds, but are more often used as resting grounds. In other places grasses come in profusely. On the dryer sites, little bluestem predominates, grows tall, and becomes rank.

It is proposed that small ponds at both shallow and artesian wells be fenced. If smooth wire is used, deer will be able to utilize the succulent feed available. At present an undesirable condition exists because of the concentration of cattle at the wells. Bermuda grass is trampled out in spots, exposing the bare sand, and the edges of the ponds are closely cropped so that often no plants remain. Fences around the ponds will correct these troubles. "Gaps" or gates are needed in these enclosures so that cattle can be admitted to reduce the vegetation to the successional stage most needed by wildlife, should it grow beyond the limits of use of deer and geese.

The following additional management practices are suggested:

1. Cottonseed cake should be fed one-half mile away from watering places. This will provide more feed and better winter protection for the cattle. As the grass is better away from established mills and the brush is denser, it will provide a more nearly even use of natural feed.

2. Bulls should be controlled so that calves are dropped between February and April; if born later, attacks from screwworms will result in heavier losses.

3. At present, the areas from which cattle are excluded are few, and the combined acreage is small. Refuge development plans consistent with wildlife values demand certain additional exclusions.

4. The removal of the excess deer by trapping for distribution to nearby points is recommended. Such "harvesting" will reduce the numbers and, incidentally, give opportunity for close study of individuals when being crated

for transport. Refinement of the census methods for deer suggested above will make it possible to determine more accurately the number and sex ratio of deer that should be harvested each year. More bucks than does should be taken so that the herd may be held to a ratio of 1 buck to 6 does, providing the Aransas Refuge is to be used as a breeding range to restock depleted areas. This ratio will provide a safety factor in the event of accidents to bucks in their greater activity during the rutting season. Reduction in deer also is related to the brushy nature of the range. The present total population is not doing any appreciable damage, but should be thinned to 3,000 or less to reduce the chance of an epizootic. Removal of the top wires of the northern boundary fence would encourage some deer dispersal and can be done if further reduction is indicated.

5. In 1939 Refuge Manager Stevenson instituted a cattle count. Without a knowledge of actual numbers on the range, management plans are not worth very much. The reduction in numbers of domestic cattle, from 8,000 in 1936 to 3,462 in August, 1940, the virtual elimination of thousands of hogs, and the removal of 500 deer in the winter of 1940–41 have reduced range pressure. There is some food competition between deer and cattle, particularly for green shoots in late winter, but the food problem does not now appear critical. Competition between deer and cattle for grass is not so serious as the figures might indicate, as the deer (usually weighing less than 140 pounds) use less than the much heavier domestic stock. Summer competition is not unduly serious as evidenced by the abundance of unused grasses of desirable species on the area. Additional water will benefit both deer and cattle by providing better distribution of both species.

SUMMARY

1. The strip-cruise method of counting deer affords more accurate results than random auto counts or drives. Its use indicated a 1939–40 winter population of 3,740 white-tailed deer (*Odocoileus virginianus*) on the Aransas National Wildlife Refuge of 47,325 acres.

2. An index count by automobile to indicate changes in herd numbers promises to be useful. Twenty minutes per day for 25 days over an 8-mile route in December was used. If such counts show a significant change in herd numbers, a cruise count should be made to check herd conditions.

3. A direct correlation was found between morning temperature in January, 1940, and the number of deer seen during an 8-mile daily trip. The percentage of overcast sky and the direction and velocity of the wind were other factors involved in this correlation.

4. A summer count indicated a sex-ratio of 92.5 bucks per 100 does.

5. Cattle both browse and graze in the winter time and do better when fed cottonseed cake between December and March; they graze during the summer.

6. Deer browse and eat green shoots in winter. In August, 1940, 72.8 per cent of their food was of grass. Data are incomplete for the other summer months. Acorns were an important fall food.

7. Use of the salt flats and wind mill sites by cattle has caused local overgrazing; change in places for supple-

mental feeding, construction of fences and exclosures, and better location of watering places have been used to offset the overgrazing. Deer also make heavy use of the salt flats and of areas near water.

8. With adequate fencing and distribution, there is ample feed for both deer and cattle at present on the refuge, although there are indications that the quality of food for cattle is not ideal and a few preferred deer foods are heavily utilized, particularly in late winter.

9. Disease is not a serious factor in either deer or cattle, but must be guarded against.

10. Accurate counts of cattle, including calves, should be made once or twice a year to facilitate administration.

11. The number of cattle on the range should depend on range conditions. This number will vary between 3,000 and 5,000 head under the present agreement.

12. The number and sex ratio of deer should be determined from counts. The deer herd should be held to not more than 3,000 by annual "cropping" trapping and distributing the excess to understocked Texas ranges for white-tailed deer. If the refuge is so used as a breeding range to restock depleted areas, more males should be removed until there is a ratio of not more than 1 buck to 6 does on the refuge.

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TECHNIQUE FOR REDUCING MAN-POWER IN THE DEER DRIVE CENSUS[1]

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The deer drive census described in the Wildlife Handbook of the North Central Region, U. S. Forest Service (1940)[2] has been used extensively since 1935 in the Lake States. It has proved to be reliable for complete counts of deer on sample areas, but scarcity of man-power at present renders it almost useless for measuring deer populations. The need for a technique of comparable accuracy, but requiring fewer men has been recognized since drives began.

A combination of the deer drive and track counts in freshly fallen snow offers a partial solution. At the suggestion of the writer, a census of this type was first tried in Minnesota during November, 1936. One census was completed successfully by State E.C.W. Camp S-62 near Hovland on the north shore of Lake Superior and others in November and December, 1941, when the Minnesota Pittman-Robertson Surveys and Investigations Project provided a number of field trials.

The technique resembles the drive census method save that three crews of two men each are assigned to tally fresh tracks crossing the "counting" lines on the sides of the area. While drivers are lining up on the driving line, each of the three crews moves quietly to one of the two outermost corners of the drive area (Fig. 1), two of the crews to the same

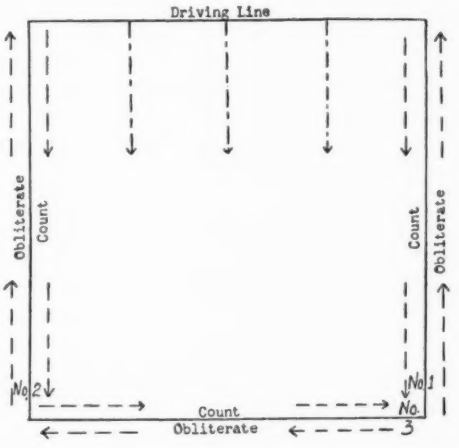

Fig. 1. Diagram to show stations and travel of counting crews in relation to driving line.

corner. Then each crew walks along one of the area boundaries where formerly counters were stationed. Each lateral boundary of the area is covered by one crew and the third side, parallel to the driving line, is covered by the remaining crew.

Each crew traverses its route as rapidly as possible and, by scraping with their feet, obliterate all visible deer tracks across the boundary since the last snowfall. Both members of a crew

[1] Work under Minnesota Pittman-Robertson Surveys and Investigation Project 11–R, Department of Conservation, Division of Game and Fish. Members of the U. S. Forest Service in the Superior and Chippewa National Forests and the Minnesota State CCC made many census trials.

[2] U. S. Forest Service. 1940. Deer Census Drive Method. Wildlife Handbook, U.S.D.A. Forest Service, North Central Region, Milwaukee, Wisconsin, Revised Edition. NF-D3-5: 1–4 (Mimeographed).

walk directly along the brushed-out boundary line, each being responsible for tracks on only one side. Where the brush is not too dense for steady walking, some advantage may be gained if only one man remains on the line to act as a guide to the other who parallels him at a distance of about ten feet; with this precaution, there is less chance of missing any widely spaced trackss made by a running deer. All tracks within a distance of ten feet on each side of the counting line should be obliterated to prevent counting them as fresh tracks. Unless the census is taken on the day following a snowfall, tracks may be so numerous that an excessive amount of time is required to obliterate them.

The driving line waits for the arrival of the two counting crews on the lateral boundaries before the drive is begun. Sufficient time also must be allowed for the third crew to obliterate all tracks on the far boundary.

When the drive commences, the two counting crews on the lateral boundaries retrace their steps and keep abreast of the driving line on either flank to eliminate the possibility of a deer being tallied more than once. The third crew waits quietly until the drive is completed before retracing its route.

The three counting crews are charged with an exceedingly important job, must be alert at all times, and must work both speedily and accurately. They should, therefore, be selected with great care. Men on the driving line are required to tally all deer seen crossing through the line.

The two-man counting crews tally each individual deer track as it is encountered crossing the area boundary. A track entering the drive area is indicated by the word "in" written after the appropriate tally. In the final computation, all such tracks are subtracted from the total number of deer driven out of the area to obtain at an accurate figure.

Occasionally, a track or trail known to have been made by two or more deer may have to be followed a hundred feet or more off the counting line before it branches and reveals the exact number of deer involved. Unless the snow is wet, it is sometimes necessary to follow the track a short distance to determine the direction in which the deer moved. Very small tracks, obviously of fawns, can be noted as such on the tally sheets, if desired.

The drivers should be instructed carefully beforehand that, upon completion of the drive, they are to walk in single file, to the nearest corner in an orderly manner so at to avoid trampling the fresh deer tracks.

A fresh snowfall is not essential but is highly desirable. On areas of low deer population density, the census may be delayed for several days after a snowfall without decreasing the accuracy of the results. Census plans, however, should be in readiness for the day after the first substantial winter snowfall. A minimum depth of four to five inches is believed to be necessary for accurate work on most areas, but experience has shown that some areas may be censused satisfactorily with a snow depth of two to three inches. If old snow several inches deep is already present, a fresh snow of only one or two inches may give satisfactory results.

During November and December, 1941, the deer drive-track census technique was employed successfully on 13 sample forest areas in two state forests, the Superior National Forest, and the

Chippewa National Forest. The sample areas differed considerably in both shape and size; nine were of 500 to 875 acres, three of 1,088 to 1,440 acres, and one contained only 386 acres. Less than 65 men were needed to do the work on most of the areas censused. The standard method usually employed more than 125 for one census. Four censuses were completed with only 40 to 50 men on the driving line. None of the 13 areas could have been censused by the former drive method because of insufficient man power.

Recent field trials showed the following disadvantages and limitations of the technique.

1. Completing the census before the hunting season in November cannot be relied upon due to possible lack of snow.

2. Best results are dependent upon snow five inches or more in depth and a fresh fall of two to three inches; otherwise the presence or absence of tracks in grassy areas and muskeg is difficult to detect.

3. Accurate work is impossible on days when the snow is drifting, particularly if a wind-swept road or trail is used as one of the counting lines. Fresh tracks are completely obliterated by drifting snow in less than a hour.

4. Observation of tracks in brushy areas is comparatively difficult and must be accomplished with extreme care.

5. On hard surfaces such as roads covered by a thin layer of snow, distinguishing deer tracks from those of rabbits, squirrels, or other animals may be surprisingly difficult.

6. When the census is necessarily delayed until December or January, deer may have begun to "yard" or may have moved to cover types different from those frequented in late fall, and the resulting count may not be comparable with those for October or November. This makes it difficult to obtain a true picture of the population trend.

7. The age and sex of deer that cross the counting lines cannot be determined.

8. A census usually must coincide with fresh snowfall. The date for the drive is therefore uncertain, and frequently plans must be changed.

9. Climatic conditions in late fall or early winter largely determine whether all drives throughout the forested area may be made at about the same time each year.

The advantages of the combined drive-track census over the old drive method appear to more than offset the limitations noted, and may be listed.

1. Necessary man power reduced by approximately 60 per cent.

2. Less time is required for both preparation and field work.

3. Efficiency of census is increased by closer spacing and supervision of men on the driving line.

4. Confusion which resulted from absorption of counters and re-spacing of drivers in the older method is entirely eliminated.

5. Simplification of "driving" enables inexperienced crews to work more effectively.

6. Deer seem to move out of an area more readily and are not so apt to "double back."

7. If proper field conditions prevail and counting crews work with great care, the accuracy of the census should be increased appreciably. Fresh deer tracks crossing a brushed boundary are much easier to observe than a leap-

ing deer seen for a fraction of a second at a distance of up to 500 feet.

The drive-track method can be applied to forest areas of any size, shape, or topography, but is especially adapted for samples of deer range bounded by roads or trails where fresh tracks may be observed most easily. It is advantageous to census by this method on long, narrow areas to reduce the required man-power on the driving line to a minimum. To illustrate, if 80 drivers are necessary to census a mile square area, only 40 are needed to drive the narrow width of an equal area two miles long and one-half mile wide. The distance travelled by both drivers and counting crews, however, would be doubled.

Use of this method on the periphery of forested deer range and in agricultural areas appears to offer a practical means for accurate population measurement. Deer habitat on such areas frequently consists of isolated patches of swampland, brush, or woodlot not over 200 acres in extent. Since these cover types are often bounded partly or completely by open fields, meadows or cultivated land, the counting of fresh tracks on such range becomes simple. A woodlot of 40 acres could be satisfactorily censused by an inexperienced crew of only 10 to 12 men.

The deer drive census as here described reduces the cost of the task by at least 60 per cent. At the same time, it is believed that organization has been simplified and accuracy of the field count increased.

PARASITISM AND MALNUTRITION OF DEER IN TEXAS

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Deaths among deer are reported from various parts of Texas every winter, the majority from the "hill country" or Edwards Plateau section; occasional deaths are noted in summer. The number reported has increased materially in recent years, indicating either that landowners are giving more attention to the deer, or that there has been an actual increase in mortality. Little or no consideration was given to deer diseases in Texas before 1939, but since then several investigations of the contributing factors have been made.

During April and May, 1939 word was received from Comal County (Edwards Plateau) that the deer were in extremely poor condition and dying on the range. In three weeks 11 carcasses were found, all heavily infested with ticks, louse flies, and screwworms. No animals were examined by the authors, but specimens of parasites and the information noted were obtained from a reliable source. Additional deer died during the winter of 1939–40. The local game warden believed that approximately 20 per cent of the entire herd perished. His estimate was not verified and no autopsies were made, but heavy infestations of ticks were found by Nicholson. It was assumed that the

deaths resulted from starvation, because of the poor condition of the range and the prevalence of emaciation among the deer.

During 1939–40 about 40 deer, mostly fawns and does, died on a 5,000-acre ranch in Guadalupe County in the Eastern Post Oaks section. This ranch has a deer-proof fence. Field investigation revealed a shortage of food, both forage and browse. One weakened animal was taken to the A. & M. College for observation. About half of the bulk of its droppings then consisted of sand. Earlier, a rancher had found sand in the stomach of a deer dead on the range. The sand in the intestinal tract of the captive was probably ingested while the animal was grazing on short grasses or picking up acorns. A swelling beneath its jaw was diagnosed as "poverty jaw," indicating an anemic condition caused either by blood-sucking parasites or by malnutrition. Its poor condition was attributed to starvation since prompt recovery followed access to nutritious food. Later this deer was killed and autopsied, but only a few internal parasites were found.

Field investigations in 1941 revealed that a number of deer, especially fawns and does, died between November, 1940 and February, 1941 in Blanco, Llano, and Burnet counties on the Edwards Plateau. A total of about 100 deaths were reported on each of three 5,000-acre ranches that were visited. Observations indicated that the reported deaths were fewer than actually occurred. Range conditions in this area were extremely poor; acorns and browse, especially of live oak, were either scarce or lacking. The shortage of browse was attributed to deficient precipitation during the preceding spring and summer, coupled with overstocking by deer and livestock. There was little indication of overgrazing and the relatively heavy autumn rains favored a good growth of pasture grasses.

The dead deer and many of those still alive were in very poor condition. There was evidence that this might be attributed to the kinds of food available. One emaciated animal had its stomach filled with grass, which apparently does not have the same nutritive value for deer that it has for cattle and sheep. Also, there was some indication that the presence or absence of acorns was important. Acorns were very scarce on the range where the highest death rate occurred. On another range, with an abundance of acorns, there were no deaths so far as could be determined.

The lack of suitable food for deer may be attributed to shortage of rainfall at critical periods of the year and to overbrowsing by deer and livestock. The importance of overbrowsing in limiting the food supply becomes evident when the rate of stocking with livestock and deer is understood. Using several census methods, it was determined that the deer population in Comal County during 1939 was up to one deer to 15 acres. Probably the deer population is equal or higher in parts of Blanco, Llano, and Burnet counties. The stocking of ranges to capacity with livestock (about 1 animal to 15 acres) in addition to a heavy deer population has resulted in overgrazing and overbrowsing, and a consequent reduction of the better deer foods. Heavy stocking of goats seems particularly detrimental to the supply of deer food. A ranch of 8,500 acres in Blanco County, which had never been

stocked with goats, had the lowest number of deer deaths in 1940–41, and more deer than any other ranch in that section.

A two-year doe and a year-old buck, easily captured in the open in Blanco County because of their weakened condition, were brought to A. & M. College for examination on February 1, 1941. Both were killed and necropsied. The external and internal parasites found were as follows:

Deer Bot or Head Maggot (*Cephenomyia phobifer*)	Nasal passage
Biting Louse (*Tricholipeurus virginianus*)[1]	Skin
Sucking Louse (*Cervophthirius binipilosus*)	Skin
Lone Star Tick (*Amblyomma americanum*)	Skin
Brown Winter Tick (*Dermacentor albipictus*)	Skin
Common Stomach Worm (*Haemonchus contortus*)[1]	Abomasum
Thread-neck Strongyle (*Nematodirus spathiger*)	Small intestine
Thread-neck Strongyle (*N. filicollis*)	Small intestine
Small Trichostrongyle (*Cooperia punctata*)[1]	Small intestine
Small Trichostrongyle (*C. pectinata*)	Small intestine
Small Trichostrongyle (*Trichostrongylus colubriformis*)	Small intestine

[1] Many.

The lice were identified by Dr. H. E. Ewing of the U. S. Bureau of Entomology and Plant Quarantine. No louse flies were found on these two deer, but some from Comal County deer in 1939, were identified as *Lipoptena mazamae* by Dr. S. W. Bilsing of A. & M. College and Dr. J. C. Bequaert of Harvard University.

The field investigation by Nicholson indicated that the deer were suffering from starvation, and the laboratory examinations by Van Volkenberg showed that the deer had massive infestations of dangerous parasites. It was concluded that the poor condition and deaths were caused primarily by malnutrition, and that the parasitic infestations were secondary. Animals weakened from any cause are more susceptible to parasites as, apparently, a higher percentage of the larvae or infective stages are able to establish themselves in or on such animals. The deer are also progressively less able to dislodge the ticks, lice, and other external parasites by rubbing and scratching.

Lack of browse on deer ranges seem to be of significance in connection with the gastro-intestinal parasites present. All of the nematodes mentioned belong to a group which infest cattle and other grazing animals. The eggs produced by the female worms pass out with the droppings onto the ground. After a period of incubation the larvae hatch and then can climb the stems and leaves of grasses wet with rain or dew. Grazing animals become infected by swallowing the immature worms which are most abundant on short pasture grasses. The chance is remote that the worms could infest any of the browse eaten by deer; however, the local deer studied were forced to subsist largely or entirely on grass, and thus were exposed to infestations by the round worms. Deer that feed largely on browse are less likely to get such heavy infestations. Thus a scarcity of deer browse may result both in poor nutrition and in serious infestations by intestinal parasites.

Field investigations through 1941 indicated that few deer died that winter on the above-mentioned ranges. Deer trapped or killed in Blanco County were

in good condition and almost entirely free from external parasites. The range was in good condition because of abundant rainfall in the spring and summer of 1941.

It may become necessary to resort to supplementary winter feeding in certain regions of Texas where deer maintenance is important and where browse is scarce, or during unfavorable years. Infestations of parasites apparently are unimportant among deer on ranges where the animals have access to sufficient suitable food.

REFORESTATION OF ASPEN AFTER COMPLETE CUTTING BY BEAVERS

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In studies of beavers at Allegany State Park, New York (Shadle and Austin, 1939; Shadle, *et al.*, 1943), it is quite apparent that they are making serious inroads among the aspens, their chief food supply. Areas around colonies have been cleared of aspen, thus forcing the animals to use less desirable species and finally to move elsewhere due to food depletion, as cited by Hiner (1938).

It is desirable to maintain beavers in the Park and this necessitates steps to prevent exhaustion of the food supply. A study of the rate of growth of the aspen in this region seemed a fundamental step in any reforestation and maintenance procedure. The aspen stumps left by beavers in cutting were used to determine the average rate of growth and the average length of time required in these areas for the trees to produce the maximum amount of food with a minimum of "waste." The latter term here means, (a) the dry corky bark of trunks and large limbs old enough to have developed a tough hard periderm, and (b) also boles and limbs too large for beavers to manipulate. Beavers tend to avoid the corky bark even when plenty of green food material lies beneath it.

PROCEDURE

The tops of the stumps of 824 aspens felled by beavers were collected. In another study (Shadle, *et al.*, 1943) one inch of wood diameter was chosen arbitrarily as the smallest to study and used in this investigation. The stumps varied from 1 to 6.6 inches in average wood diameter, bark not included. Each segment was thoroughly dried, carefully sawed at right angles to the trunk axis, and the sawed end sanded smooth to show the annual rings clearly. Each segment was numbered (Fig. 1, *A*), and the longest (*BB'*) and shortest (*CC'*) wood diameters were located, marked, and measured on the smooth surface to calculate average diameter. The average thickness of the bark also was determined. An average radius (*OD*) then was located and drawn on the segment, the annual rings counted along this radius, and the age of the tree recorded on the stump (*E*).

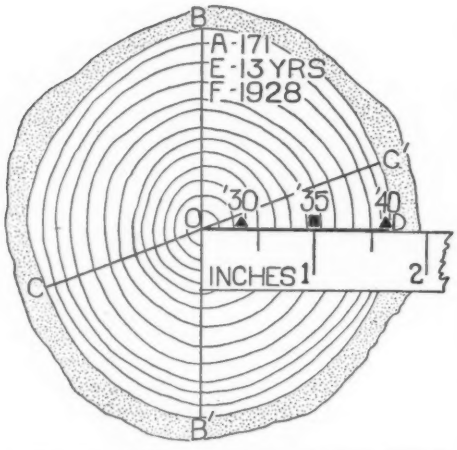

Fig. 1. Methods of measuring and marking stump segments of aspen cut by beaver. *A*, number of stump segment; *BB'*, greatest diameter; *CC'*, least diameter; *OD*, average radius; *E*, age of tree; *F*, first year of growth; ▲, calendar years ending in "0"; ■, calendar years ending in "5." Edge of ruler is along average radius and end of ruler at the center of the first annual ring of wood. Count of the rings of wood growth in successive half-inches shows that this tree required 4 years to produce the first inch of wood diameter and 3.5 years each for the second and third inches.

To increase the definition of the rings, hot paraffin was applied along the average radius, and the end was heated over a flame until the excess paraffin melted and soaked into the wood. Magnification was used to distinguish true annual rings from false ones and for counting rings close together.

By knowing the exact year when each tree was felled, the annual ring of any particular year could be determined. The year of the first annual ring of wood growth was recorded on the stump segment (Fig. 1, *F*) and, to facilitate later work, the wood growth of every calendar year ending in "0" was colored and dated in red and the wood growth of each intervening year ending in "5" was indicated in blue (Fig. 1, along *OD*).

The final step was to determine the number of years required by the tree to produce each successive inch of wood diameter. With the edge of a ruler along the average radius and one end at the center of the first annual ring, the number of annual rings in each half inch provided this information. The results are summarized in Tables 1 to 3.

Since dry, corky bark is seldom eaten by beavers, the bark of these aspen stump segments was examined to de-

Table 1.—YEARS OF GROWTH REQUIRED PER INCH OF WOOD DIAMETER IN ASPEN.

	First inch	*Second inch*	*Third inch*	*Fourth inch*	*Fifth inch*	*Sixth inch*
Average	7.99	5.44	4.84	4.31	4.82	5.00
Mode	8.00	4.00	4.00	4.00	—	—
Median	7.50	5.00	4.29	4.00	—	—
Range	2.75–18.00	2.00–14.00	1.50–11.50	2.00–8.75	2.50–8.00	4.00–6.00
Number of stumps included	824	515	196	53	14	2

Table 2.—AVERAGE ANNUAL RING WIDTH PER SUCCESSIVE INCH OF WOOD DIAMETER.

Inch of wood diameter	*Average width of annual ring*
First	0.13 inches
Second	0.18
Third	0.21
Fourth	0.23
Fifth	0.21
Sixth	0.20

Table 3.—WOOD DIAMETER AND TREE AGE.

Average wood diameter	*Average age of tree*
1 inch	7.99 years
2 inches	13.43
3 inches	18.27
4 inches	22.58
5 inches	27.40
6 inches	32.40

termine the diameter, thickness of bark, and usual age at which the trees began to produce cork. It became corky when more than 0.19 inches in thickness. Definite statements about the size or age of the trees when this thickness of bark was attained cannot be made, because of variations, but bark 0.19 inches thick was common on trees having a wood diameter of about three inches and production of corky material in quantity usually began at approximately the twentieth year. Thereafter it accumulated with the increase in size and age of the trees.

DISCUSSION

At Allegany State Park there are two species, the quaking aspen (*Populus tremuloides*), and the large toothed aspen, (*P. grandidentata*). Since there may be growth differences between the species, the stump segments were marked with specific names when possible to determine them from buds or leaves not completely removed by the beavers. All felled trees so marked were *P. tremuloides*. These showed as much variation in thickness of bark and years required to produce the successive inches of wood growth. Among the unidentified stump segments some possibly were *P. gradidentata*.

P. tremuloides, is by far the more numerous and is distributed generally over the Park, but occurs in larger stands in lowlands and along streams, the typical locations for the beaver colonies. *P. grandidentata* seems to be restricted largely to higher land and hilltops where not available to beavers. This is also true in West Virginia, according to studies by Pierle (1941).

Even if some of our segments were *P. grandidentata*, their effect on the final results was practically negligible. (1) The differences in distribution of the two species makes it comparatively certain that few segments could have been *P. grandidentata*. (2) There was such great variation in bark thickness and years required to produce successive inches of wood growth among stump segments definitely known to be *P. tremuloides* that the extremes were not due entirely to *P. grandidentata*. (3) Large numbers of segments were examined and any differences due to the possible presence of *P. grandidentata* were obscured by the greater number of *P. tremuloides*.

Contrary to general belief that all aspen trees grow rapidly from their beginning, the data reveal that aspens at Allegany State Park grew slowly even during the first inch of wood production which required an average of about eight years. This time is substantiated by the mode (8 years) and the median (7.5 years) in this wood diameter class. Thereafter the growth rate gradually accelerated to a maximum during the production of the fourth inch of wood, for which only a little more than four years were required. Thenceforth the rate of growth tended to decrease slightly and possibly to become more or less constant (Fig. 2); the data are insufficient to determine this point.

The difficulties experienced by small, young aspens in becoming established may account for their slow growth during production of the first inch of wood, when they are probably affected more readily by environmental changes than are older and well established trees. Temperature, rainfall, ravages of insects or diseases, effects of wind or snow,

browsing, and the density of the stand are a few factors which may act with more pronounced results on the smaller and younger trees.

Even though beavers usually avoid eating corky bark, they frequently fell trees with much cork to get at the leaves and the bark of twigs and small branches which are free of cork. The

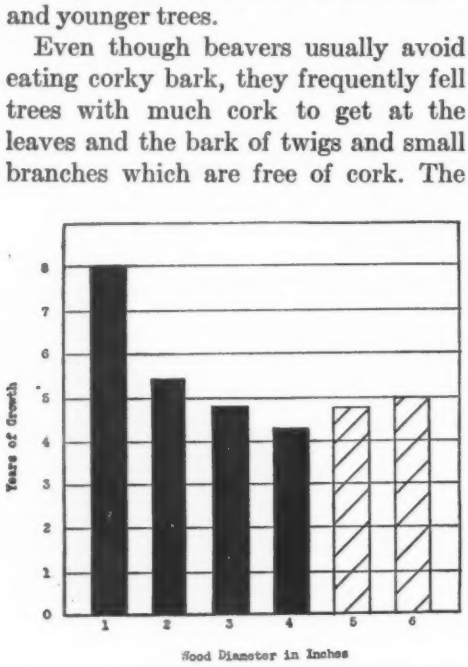

Fig. 2. Average years per inch in diameter of wood growth of aspen; few data were available for the 5- and 6-inch classes.

bark of most trees not over three inches in wood diameter (up to about 20 years old) can be utilized completely for food. Moreover, those up to and including this size and age can be readily manipulated by the beavers and all of the wood may be utilized in the construction of dams and lodges. Larger and older trees ordinarily are only partly utilized, because of the corky bark on the trunks and large branches. Trees over four inches in wood diameter and about 24 years old are used only partially, the trunk and large branches being too large for beavers to manipulate.

At Allegany State Park it should take, therefore, approximately twenty years to produce aspen trees of the optimum age and size for complete use by beavers. Whether all the bark is used or not depends upon the feeding habits of the beavers under observation; those in the Park usually make complete use of their available food supply, including all bark on a three inch tree. Aldous (1938) reported utilization of only 26 per cent of the available food of nine inch trees and 50 per cent of three inch trees.

An extensive study of the amount of food produced by aspen trees of various sizes and the corresponding percentages of utilization and waste of the available food was made by Aldous (1938). He found a markedly "greater percentage of total utilization of the available food in the 1, 2, and 3 inch stump diameter classes," and the quantity of food they produced was small in comparison with that from the larger trees "even though the latter were only partially used." His data show that 6-inch trees, 35 years old, afforded the greatest amount of available food, about five and one-half times as much as 3-inch trees which are 20 years of age. For quantity production of beaver food and, also, from the standpoint of efficient forestry it would seem preferable to allow the trees to grow for more than 20 years. Therefore, even though 20 years has been referred to as the optimum age *for complete utilization*, 35 years is the optimum from the standpoint of the amount of beaver food produced.

Allowing the trees to grow for more than 20 years and to become larger than three inches does appear to be a more efficient reforestation procedure, Aldous reported the greatest proportion of complete wastage in trees 4 to 6 inches in diameter due to the failure of these

lighter trees to crash through surrounding growth and the resultant high frequency of lodging. Efficient forest management could overcome this difficulty by allowing sufficient space to prevent the lodging of the trees as they fall. More space among trees would mean fewer trees in a given area. It is questionable whether fewer 6-inch trees, properly spaced to prevent lodging, would furnish more food than the greater numbers of 3-inch trees which could be grown on the same area.

There are several problems of aspen reforestation in which the native fauna has a role:

1. It is difficult to prevent beavers from entering an area before the trees are old enough to furnish a sufficient supply of food to maintain the beaver colony for a reasonable length of time.

2. Even if reforestation of areas in the park is undertaken immediately, the present beaver population probably would not benefit greatly. They may so deplete their food supplies that they will have to migrate into other regions, possibly out of the park.

3. The number of deer in the Park from 1936 to 1940 resulted in overbrowsing and distinct damage to several types of trees, as pointed out by Shadle and Stullken (1942). The deer situation has improved, but they feed freely on the leaves and twigs of aspen, and might seriously retard aspen reforestation, just as they have damaged evergreen reforestation in the same area.

The local aspens do not develop root suckers to any extent, and growth from root suckers is reported to remain shrubby. Propagation from natural seed dispersal would be uncertain as to time and spacing of resultant trees. Production of a maximum of food in a minimum of time must, of necessity, be by artificial reforestation, either by seeds or cuttings. Wettstein (1937) found that aspen is commonly regenerated from root suckers, but after several generations of vegetative propagation it is desirable to interpose a generation from seed. Seedlings from known parents of *Populus tremula* and *P. tremuloides* showed wide differences in rate of growth and straightness of stem, necessitating care in choice of seed for propagation. Details about collection and storage of aspen seed have been outlined by Wettstein (1936).

Artificial propagation by seed at Allegany State Park would be long and laborious, whereas propagation from selected cuttings would more likely give the desired results with less time and effort. Spreeman (1940) stated that it is "impossible to propagate pure strains of *Populus* except through cuttings." Trees of rapid growth which do not develop outer layers of tough, hard periderm until large and old in the swampy conditions surrounding most beaver colonies would be best for cuttings to produce beaver food. Pure strains of *Populus* exhibiting these desirable characteristics could be maintained by cuttings and would answer the problem of aspen reforestation after depletion by beavers.

SUMMARY

1. For this study 824 stump segments varying in size from 1 to 6.6 inches in average wood diameter were collected at Allegany State Park, New York. Beavers had felled the trees from these stumps.

2. An average of 8 years was needed to produce the first inch of wood diam-

eter and 32.4 years to yield trees six inches in diameter.

3. Production of corky bark in quantity began when the bark was 0.19 inches thick and the trees about 20 years old, and three inches in wood diameter.

4. *Populus tremuloides* is distributed widely over the entire park with larger stands in the lowlands and along streams where available for beaver food. *P. grandidentata* is restricted largely to higher land and hilltops, and practically unavailable to beavers.

5. Approximately 20 years are required to produce trees at the optimum age and size for complete utilization by beavers, and approximately 35 years for trees having the greatest amount of available food.

6. Whether the available food of the aspen trees is completely utilized depends upon the varying degrees of wastefulness in the feeding habits of individual beavers.

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Storage cabinet and racks with vials for reference collection of seeds.

BRIEFER ARTICLES

CLASSIFYING AND STORING A REFERENCE COLLECTION OF SEEDS

A seed collection for reference purposes became necessary for the Arizona Federal Aid 9-R field investigations to provide immediate answers on questions relating to the food habits of the various game birds. We realized that the Food Habits Division of the Fish and Wildlife Service often had more material on hand than they were able to identify immediately. Many of the plants on which our game birds and animals feed are peculiar to Arizona and may not be represented in the collections at Washington. By gathering and identifying seeds of native plants the study of local game species was greatly facilitated.

The collection was started in 1940; 220 species of seeds have been collected and identified to genera, and to species in most instances.

The thoroughly dried seeds are stored in 1- and 2-ounce square glass bottles with a few crystals of di-chloricide (paradichlorbenzene) for preservation. A label on the side of each bottle bears the genus and species names, place and date of collection, and the collector's initials. These bottles are satisfactory for storage because they hold many seeds, but are too large for convenience in reference and identification.

A complete list of all seeds collected was compiled alphabetically by genera. Each sample was given a number under its alphabetical group, and the number of the storage rack in which that seed is found follows the name, thus: A1 *Acacia constricta* 3; C34 *Curcubita digitata* 4; Y2 *Yucca elata* 18. The alphabetical group number was attached to the bottle cap. Such listings leave unlimited room for additions to each alphabetical group.

As the collection was enlarged it became apparent that a further classification for ready reference was needed so that the seeds would be readily available in food habit studies. Experimentation resulted in the following system. The seeds were first divided into 15 types as to shape: irregular; filiform; ovate; rhomboidal; club; reniform; globose; disk; ovoid; 3-angle; flat; thin or wafer-like; winged; plumed; drop or pear shaped; and minute seeds. A small portion of each sample was placed in a round 2-dram vial with screw cap and the identifying number was placed on the vial. Using the small vials, each shape class was then divided into color classes, and those of each color class further arranged in a sequence of diminishing sizes. The large bottles were placed on cupboard shelves as a reserve supply for the small vials.

To keep the small vials in proper order, racks and a storage cabinet were designed. The racks were made of $1'' \times 2'' \times 14''$ oak strips. Along the center line of each strip 15 holes $1\frac{5}{8}''$ deep were drilled with an $\frac{11}{16}''$ wood bit. These holes are slightly larger than the vials. A section $\frac{5}{16}''$ wide by $1\frac{5}{8}''$ deep (from the top) was then cut away from the right side of each strip, making an open slot along each hole. The section removed did not extend to the center of the holes so that a lip was left on the side of each hole to keep the vials from falling out. This side opening makes it possible to view the contents of the vials while in the rack. To give better lighting to the contents of the vials, a piece $\frac{3}{16}'' \times \frac{3}{4}''$ was rabbeted out of the left side of each strip $\frac{1}{4}''$ from the bottom.

A small tab was attached to the front of each rack. Labels bearing the rack number and the shape of the seeds in the rack were cemented to the front tabs. Each seed classification was given a number and as racks are added a sub-letter is attached to the label on a rack. The pine cabinet is $15\frac{1}{2}''$ deep with four shelves each holding eight racks. A total of 480 samples thus may be stored in a cabinet with outside measurements of $16'' \times 9'' \times 14\frac{1}{2}''$ (Pl. 12).—Lynn A. Griner, 5 *N.* 17th *Ave., Phoenix, Ariz.*

THE SENEY BULRUSH PICKER

The bulrushes, hardstem, softstem, and three-square (*Scirpus acutus*, *S. validus*, and *S. americanus*), are valuable plants in marsh restoration work. They provide seed as food and stems as nesting material for waterfowl, and are useful in reducing dyke erosion. The interlacing rootstocks bind the soil and the stems lessen the destructive action of waves. In addition, muskrats relish eating the rootstocks, and deer and geese have been known to browse freely on the succulent young culms.

Bulrush stands are best established by planting seed. Seeding in itself is fast and successful, but the collection of seed is difficult. Most situations where seed is collected are too wet, stony, or inaccessible, or too small in size for successful harvesting with farm machinery. Stripping the ripe heads by hand is the most common method, but is costly and time consuming. To expedite hand collecting, a picker (Fig. 1) was designed by the writer. In one season on the Seney National Wildlife Refuge in Upper Michigan its usefulness has been proved as it collects ripe seed heads about five times as fast as by hand.

The picker can be constructed easily by a mechanic or metal worker from materials found in any garage or metal shop.

The steps in construction are as follows:

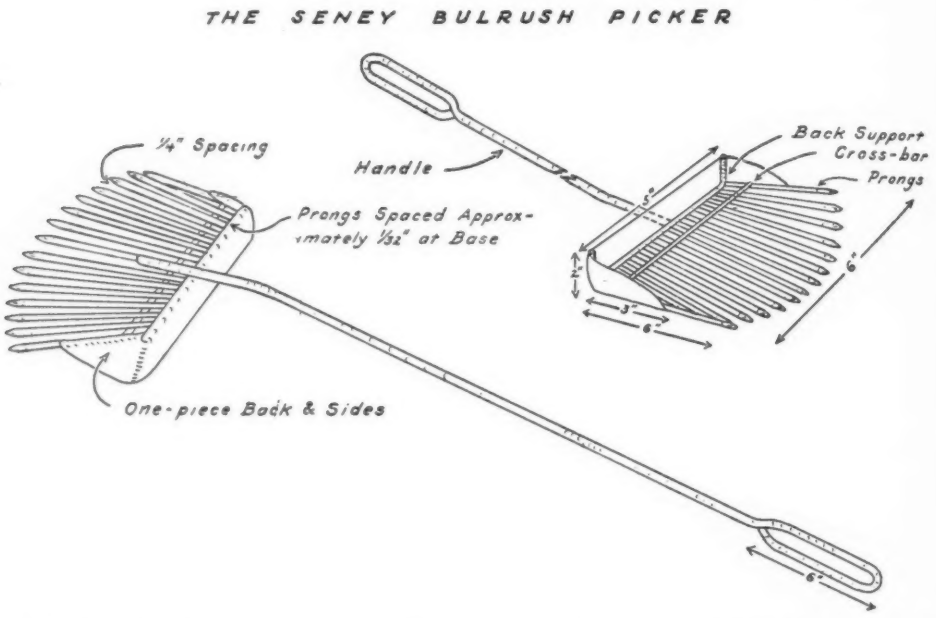

Fig. 1. Seney bulrush picker. Overall length, 24 inches; contains 30 prongs, but only 15 shown. Materials: back and sides, 28 gauge galvanized sheet metal; other parts of hi-test steel welding rod as follows: back support, $\frac{3}{16}$ inch; prongs and cross bar $\frac{1}{32}$ inch; handle, $\frac{1}{4}$ inch.

Cut prongs, cross-bar, back support, handle and galvanized back to size; sharpen prongs on an emery wheel; space prongs properly on a flat metal surface; weld prongs lightly to cross-bar; weld back support to prongs; add galvanized metal back; attach handle. For sturdiness, spot weld all contact points.

Collecting is aided materially by shaping the prongs into an arc and bending the handle slightly, as shown. The picker is held in the hands and pushed through the bulrush stems. Since the culms are slender near the fruiting panicles, they are easily engaged by

the prongs and an upward thrust removes the fruiting heads. By repeated thrusts, the accumulated heads are wedged or held loosely in the picker and then scraped by hand into a receptacle. Some loss of seed occurs when fruiting heads are bursting with ripe seed, but this is negligible if harvested early in the collecting season. Careful examination of the fruiting heads will indicate the best time to collect mature seed.—JOHN L. SYPULSKI, *Seney National Wildlife Refuge, U. S. Fish and Wildlife Service, Germfask, Michigan.*

OCTOBER FOODS OF RUFFED GROUSE IN MAINE[1]

This study is based on the contents of 34 crops and gizzards with food of the ruffed grouse (*Bonasa umbellus*) collected in Maine during October, from 1936 to 1939. Material was analyzed by the volumetric method of the U. S. Biological Survey (1938). The foods were dried to a moisture content approximating that when eaten, the volume of large seeds and fruits was measured by their displacement of corn meal, and smaller items were firmly packed into a graduated tube reading to 0.1 cc.

Plant foods were grouped as buds, leaves, or fruits. Items other than grit that comprised one per cent or more of the total food were given percentage values. Grit was computed as a percentage of the total contents of the digestive tract.

Frequency of occurrence is a valuable index of the importance of foods in connection with volumetric data, but numerical ratings could not be given because the contents of nine crops had been combined by the collectors which precluded separating the items in each.

The 108 foods identified represented 79 species or larger taxonomic groups, and of these, 63 formed one per cent or more of the total food (Table 1). The predominance and wide variety of plant material (98.2%) over animal (1.8%) in general substantiate the findings of Kelso (1935), Gross (1937), Nelson, Clarke, and Bailey (1938), and Kuhn (1940) as to the diet of the ruffed grouse.

[1] Contribution from Maine Cooperative Wildlife Research Unit, Orono, Maine. Maine Department of Inland Fisheries and Game, University of Maine, American Wildlife Institute, and U. S. Fish and Wildlife Service, cooperating. The Departments of Botany and Entomology, University of Maine and the U. S. Fish and Wildlife Service gave helpful aid in identifying food materials.

Fruits, leaves, and buds comprised 41.7, 36.9, and 13.9 per cent, respectively. Leaves were not dry when eaten, but fruits often were and would have been of greater significance had all the analyses been made with equally dry material. Woody buds are of lesser volume, but made up an important part of the October food.

The importance of availability in the taking of food is well shown with clovers. These predominantly herbaceous plants remain green until late fall, often after snowfall, and the leaves are high in the October diet in Maine (13.4%). Kelso (1935) found them relatively unimportant from December through March in New York; Gross (1937) reported about 2 per cent of clover leaves among fall foods in New England; and Nelson, Clarke, and Bailey (1938) found less than one per cent during late fall in Virginia, as did Kuhn (1940) in Pennsylvania.

Leaves and buds of aspens comprised about one-eighth of the food. Buds of bigtooth aspen (3.7%) predominated, whereas more leaves of quaking aspen (7.6%) had been eaten. *Populus* also proved important in New York (Kelso, 1935) and Pennsylvania (Kuhn, 1940), rating 12.5 and 6.4 per cent, respectively.

Pomes and nutlets of hawthorn were taken in a proportion similar to that found in New England by Gross (1937), but in larger percentage than in studies in Pennsylvania, Virginia, and New York. Hosley (1939) suggests that the nutlets are often retained in the gizzards for a considerable period, thus giving them undue importance in analyses. As most of the fruit in this series was taken from crops the volume is fairly representative.

Yellow birch buds are of considerable importance as winter food, but it was note-

Table 1.—SIGNIFICANT OCTOBER FOODS OF RUFFED GROUSE IN MAINE.

(34 Digestive Tracts)

Plants	*Parts eaten*	*Percentage of total food*	
		Items	*Groups*
Clover (*Trifolium*)	Leaves	—	13.4
T. repens	Leaves	9.7	
T. pratense	Leaves	1.0	
T. spp.	Leaves	2.7	
Aspen (*Populus*)	—	—	12.2
P. grandidentata	Mostly buds, leaves	3.7	
P. tremuloides	Leaves	7.6	
P. spp.	Buds	.9	
Hawthorn	—	—	9.7
(*Crataegus* spp.)	Fruit	8.8	
	Leaves	.9	
Yellow birch (*Betula lutea*)	Buds	—	8.3
Dwarf cornel (*Cornus canadensis*)	Fruit	—	6.5
Maple (*Acer*)	—	—	5.3
A. pennsylvanicum	Fruit	4.7	
A. saccharum	Buds	.3	
A. spicatum	Buds	.2	
A. rubrum	Fruit	.1	
Canada mayflower (*Maianthemum canadense*)	Fruit	—	5.2
Apple (*Malus* spp.)	—	—	5.1
	Fruit	4.1	
	Leaves	1.0	
Checkerberry (*Gaultheria procumbens*)	—	—	2.8
	Fruit	2.7	
	Leaves	.1	
Fungi	—	—	2.4
Bramble (*Rubus* spp.)	Fruit	—	2.4
Arrow-wood (*Viburnum*)	Fruit	—	2.2
V. Opulus var. *americanum*	Fruit	.9	
V. alnifolium	Fruit	.1	
V. spp.	Fruit	1.2	
Sedge (*Carex* spp.)	Fruit	—	1.8
Wood fern (*Dryopteris spinulosa*)	Fronds	—	1.5
Violet (*Viola* sp.)	Fruit	—	1.2
Galls	—	—	.9
Miscellaneous	—	—	14.9
(45 species or larger groups)	Buds	1.0	
	Leaves	8.2	
	Misc. plant parts	5.7	
Unidentified	—	—	2.4
			98.2
Animal Food: Insects	—	—	1.8

worthy to find them taken so extensively in autumn. Three-fourths of the food from one crop collected in April (excluded here) was composed of buds of yellow birch. Kelso (1935) found that birch buds made up 12.3 per cent of the winter food in New York, but Gross (1937) and the workers reporting upon Virginia and Pennsylvania birds ranked them as an unimportant food in autumn.

Fruits of dwarf cornel and Canada mayflower are usually abundant in Maine during the fall, readily available to ruffed grouse, and were taken frequently. Gross (1937) found them important in his extensive study of New England grouse.

Maple provided a small part of the diet, samaras of *A. pennsylvanicum* (4.7%), predominating. Foods derived from maples are insignificant in the reports of investigators cited.

The amount of apple products taken, chiefly fruit (4.1%), tends to verify the belief of many upland bird hunters that grouse frequent old orchards to feed. A seasonal difference in the parts consumed is indicated by the relatively high percentage (6%) of twigs and buds in winter reported by Kelso for New York (1935).

Fruit of the checkerberry is rather important (2.7%). It is available until snow-cover, which rarely comes in October. Leaves and fruits of this species are important (6.11%) on the George Washington National Forest, Virginia (Nelson, Clarke, and Bailey, 1938).

A notable contrast between the Maine findings and the published records is in the absence of acorns. For New England as a whole, these are important in the diet of ruffed grouse as determined by Gross (1937). Their absence in this series of ruffed grouse stomachs is explained by unavailability. In northern and central Maine, where all but three of the stomachs used in the present study were obtained, oaks are scarce. They are common in many parts of the states where birds studied by Gross were collected.

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—WALTER H. KITTAMS, *Maine Cooperative Wildlife Research Unit, University of Maine, Orono, Maine.*

FOOD PREFERENCES OF BLACK HILLS DEER

Analyses were made of the stomach contents of 101 deer killed in the northern Black Hills of South Dakota and Wyoming during 1941, 79 white-tail deer (*Odocoileus virginianus macrourus*) and 22 mule deer (*O. hemionus*). Of these deer, 33 were killed by poachers and illegal hunting, 29 were hit by cars on highways, 22 were legal hunting season kills, 8 had been taken by predators, and 9 were caught in fences or involved in similar accidents. Three-fourths of the stomach samples were collected by the authors, and the remainder by interested cooperators in the South Dakota and Wyoming game departments, the U. S. Forest Service, and the U. S. Fish and Wildlife Service.

The stomach content samples varied in amount from a pint to a gallon, usually being the entire content of the paunch. Each was washed on a series of 2-, 4-, 6-, and 8-mesh screens. (For making identifications of materials present a plant collection in formalin afforded specimens in forms similar to those encountered in the stomachs.) Considerable herbaceous material in the food was not readily identifiable, and in Table 1 is listed as "weeds—unidentified." This category, however, probably includes several species of more importance than some of those identified.

Results from the analyses were grouped arbitrarily in three lots to represent important divisions of the year from the standpoint of management: the most critical winter period (January through April); the summer (May through September); and the season following heavy frosts but preceding the covering of surface vegetation by snow (October through December). Except for one storm in mid-April, the depth of snow was less than 12 inches, and south exposures were generally bare; therefore, the study does not show the foods that would be utilized with heavy snowfall. For example, more than half of the food taken in the January through April period and 65 to 75 per cent of that eaten in October, November, and December would have been covered by less than a foot of snow.

Only two samples of mule deer food were obtained from January to September inclusive, and these are omitted from the summary.

Table 1 shows that the principal food plants during the January–April period were bearberry (kinnikinnick), buck brush (wolfberry or snowberry), ponderosa pine, Oregon grape, rose, service berry, weeds, grass, and wheat; from May to September, rose, aspen, weeds and grass; and during October to December, Oregon grape, bearberry, buck brush, juniper, snowbrush (deer brush or mountain balm), rose, weeds, grass, and oats.

Little aspen was taken except when it was leafing out in the spring. New growths and leaves of rose were utilized during the spring and summer, and rose hips predominated during the fall and winter. Buck brush was used only when it had berries; in general wild fruits of all species appeared highly palatable. Snowbrush and Oregon grape were used until they turned brown or purple in mid-winter.

Studies made by trailing deer in snow indicated that a few of the more abundant woody plants are used but little or not at all; these included beaked hazel, russet, buffalo-

Table 1.—STOMACH CONTENTS OF 99 BLACK HILLS DEER (PERCENTAGES).

Plant Species	Whitetail Deer						Mule Deer	
	Jan.—Apr.		May—Sept.		Oct.—Dec.		Oct.—Dec.	
	17 Deer		8 Deer		54 Deer		20 Deer	
	Frequency[a]	Volume[b]	Frequency	Volume	Frequency	Volume	Frequency	Volume
Bearberry (*Arctostaphylos uva-ursi*)	71	23.8	—	—	76	15.3	85	11.2
Ponderosa pine (green) *Pinus ponderosa*	59	11.1	25	0.1	15	1.8	10	0.5
Buck brush (*Symphoricarpos occidentalis*)	59	10.1	62	1.8	50	9.9	45	10.0
Oregon grape (*Odostemon repens*)	41	6.7	25	0.4	69	15.0	80	29.4
Wild rose (*Rosa*)	47	6.2	100	22.2	46	2.6	55	2.8
Serviceberry (*Amelanchier*)	59	5.6	50	2.9	41	1.9	40	1.0
Snowbrush (*Ceanothus velutinus*)	6	2.6	12	tr.	28	4.0	40	6.7
Bur oak (*Quercus macrocarpa*)	53	2.5	—	—	9	0.3	5	1.3
Aspen (*Populus tremuloides*)	12	1.8	62	21.0	30	0.3	30	0.4
Creeping juniper (*Juniperus horizontalis*)	18	1.5	—	—	—	—	—	—
Willow (*Salix*)	24	1.3	—	—	13	0.6	10	3.2
Ground juniper (*Juniperus communis*)	18	0.9	12	tr.	33	4.5	55	8.5
Paper birch (*Betula papyrifera*)	12	0.9	—	—	—	—	—	—
Hawthorn (*Crataegus*)	6	0.1	—	—	—	—	—	—
Fringed sage (*Artemisia frigida*)	12	0.1	—	—	2	0.1	—	—
Ponderosa pine (dry) (*Pinus ponderosa*)	53	0.1	62	0.4	48	0.4	60	0.3
White spruce (*Picea glauca albertiana*)	6	0.1	12	tr.	15	0.1	—	—
Twinflower (*Linnaea americana*)	—	—	12	tr.	20	3.2	25	0.6
False tarragon (*Artemisia dracunculoides*)	—	—	—	—	4	0.6	—	—
Rocky Mountain sumac (*Rhus cismontana*)	6	tr.	—	—	4	0.2	5	tr.
Grouse whortleberry (*Vaccinium scoparium*)	—	—	—	—	2	0.2	5	tr.
Snowberry (*Symphoricarpos albus*)	—	—	—	—	4	0.1	—	—
Meadowsweet (*Spiraea lucida*)	—	—	—	—	2	tr.	—	—
Green ash (*Fraxinus lanceolata*)	—	—	—	—	2	tr.	5	tr.
Red willow (*Cornus baileyi*)	—	—	12	3.1	4	tr.	—	—
Honeysuckle (*Lonicera glaucescens*)	—	—	—	—	2	tr.	—	—
Chokecherry (*Prunus melanocarpa*)	6	tr.	25	tr.	—	—	—	—
Ironwood (*Ostrya virginiana*)	6	tr.	—	—	—	—	—	—
Beaked hazel (*Corylus rostrata*)	6	tr.	12	0.2	—	—	—	—
Squawbrush (*Ceanothus mollissimus*)	—	—	12	1.2	—	—	—	—
Unidentified browse	—	—	25	1.8	—	—	—	—
TOTAL BROWSE		75.4		55.6		61.1		75.9
Weeds (unidentified)	82	3.0	100	24.5	85	12.1	80	7.8
Everlasting (*Antennaria*)	24	2.9	—	—	48	6.3	30	1.0
Pasque flower (*Pulsatilla ludoviciana*)	6	2.6	12	1.1	—	—	—	—
Water hyssop (*Bacopa rotundifolia*)	12	0.1	—	—	4	1.1	—	—
Horsetail (*Equisetum*)	6	tr.	—	—	—	—	—	—
White clover (*Trifolium repens*)	—	—	12	tr.	30	3.1	20	1.4
Sweet clover (*Melilotus*)	—	—	—	—	6	1.2	5	0.8
Asparagus (*Asparagus officinalis*)	—	—	—	—	2	0.6	—	—
Alfalfa (*Medicago*)	—	—	—	—	2	0.4	—	—
Bedstraw (*Galium*)	—	—	12	0.4	6	0.2	—	—
Lupine (*Lupinus*)	—	—	—	—	9	0.1	10	tr.
Yarrow (*Achillea lanulosa*)	—	—	—	—	4	tr.	5	tr.
Stonecrop (*Sedum stenopetalum*)	—	—	—	—	2	tr.	10	tr.
Sunflower (*Helianthus*)	—	—	—	—	2	tr.	5	tr.
American columbo (*Frasera speciosa*)	—	—	—	—	—	—	10	3.0
Carrion flower (*Smilax lasioneuron*)	—	—	—	—	—	—	5	0.3
Chickweed (*Cerastium*)	—	—	—	—	2	tr.	—	—
Anemone (*Anemone*)	—	—	—	—	2	tr.	—	—
Loco (*Oxytropis*)	—	—	12	0.2	—	—	—	—
Wild strawberry (*Fragaria*)	—	—	12	0.2	—	—	—	—
TOTAL WEEDS		8.6		26.4		25.1		14.3
Grass (unidentified; mostly *Poa*)	76	7.0	88	12.0	76	3.3	75	6.2
Wheat (*Agropyron triticum*)	18	5.6	—	—	2	0.6	—	—
Oats (*Avena sativa*)	6	0.1	12	1.9	13	3.8	—	—
Corn (*Zea mays*)	6	0.1	—	—	6	2.3	—	—
Barley (*Hordeum vulgare*)	—	—	—	—	7	0.6	—	—
TOTAL GRASSES		12.8		13.9		10.6		6.2
Old-man's-beard (*Usnea*)	24	2.9	—	—	31	1.1	35	1.6
Fungi (unidentified)	—	—	62	4.0	31	2.1	25	2.0
TOTAL FUNGI AND LICHENS		2.9		4.0		3.2		3.6

[a] Frequency = percentage occurrence among the stomachs studied in each period.
[b] Volume = in per cent of stomach contents.

berry (*Lepargyrea canadensis*), skunkbush (*Rhus trilobata*), lead plant (*Amorpha*), snowberry, currant, gooseberry, paper birch, and ironwood. Dry needles of pine and spruce were probably taken incidentally while the deer fed on such low shrubs as the bearberry

and Oregon grape, just as dry twigs were eaten occasionally with the saprophytic old-man's-beard or tree moss.

The balance between browse plants, weeds and grasses remained fairly constant throughout the year as shown by average abundance in the stomachs.—RALPH R. HILL, *Black Hills National Forest, Deadwood, S. D.*, and DAVE HARRIS, *South Dakota Department of Game and Fish, Deadwood, S. D.*

EVIDENCES OF RACCOON MOBILITY OBTAINED BY TAGGING

During the autumn of 1941 the Arkansas Game and Fish Commission, under the provisions of the Federal Aid to Wildlife Restoration Act, conducted a raccoon livetrapping project on the U. S. White River Migratory Waterfowl Refuge in the southeastern part of the state. A total of 256 raccoons, evenly divided as to sex, were taken, tagged, and released on 21 other refuges throughout Arkansas. During the 1941–42 open season (December 1 to January 31) tags from 19 of these raccoons were returned by hunters and trappers. The distances covered in wanderings after release are of considerable interest and in a few cases almost startling. A summary of the results follows, records for three being omitted for lack of sufficient information:

Tag No.	*Sex*	*Released*	*Interval in days*	*Miles traveled*
6	♂	Oct. 3	75	75
10	♂	Oct. 6	?	7
29	♂	Oct. 8	?	33
45	♂	Oct. 11	98	21
60	♂	Oct. 19	47	8
71	♂	Oct. 19	43	27
75	♂	Oct. 19	44	9
82	♂	Oct. 19	?	11
119	♂	Nov. 1	54	4
158	♂	Nov. 10	63	3
35	♀	Oct. 11	62	8
90	♀	Oct. 23	?	9
165	♀	Nov. 16	?	8
207	♀	Dec. 4	?	2
220	♀	Dec. 8	43	13
226	♀	Dec. 12	?	16

The interval is that between the dates of release and capture. All distances were measured as straight lines between the points of release and capture. Information on the location of the kill and extent of travel in a few instances was obtained from refuge keepers and county wardens, but most of the records were gathered by corresponding with the hunters and trappers. All reports were closely checked on detailed maps, so that the distance records can be considered reasonably accurate. The only possibility of significant error lies in the veracity of statements by hunters, and this possibility is largely discounted. It is doubtful that any tags would have been returned from raccoons killed illegally.

The female raccoons apparently wandered much less than the males; and many of them probably remained on the refuges, since fewer tags from female raccoons (7) were recovered than from males (12) and comparatively shorter distances were recorded. This conclusion is further substantiated by reports of notably increased raccoon sign on the refuges, and by an actual record of a tagged female rearing a litter within 200 yards of where she was liberated.

There is no indication of any directional or homing instinct. The raccoons followed streams, or sometimes traveled overland from one watercourse to another, and in all directions. One particular individual (no. 71), after being released on a small stream in north-central Arkansas, crossed the upper White River and continued eastward along another small stream where it was finally captured.

An explanation of these instances of exceptional mobility lies, perhaps, in the contrasting environments of the White River Refuge and the other refuges where the releases were made. The former is a broad, flat, bottomland, heavily timbered, and possessing, besides the meandering river, many shallow lakes, bayous and sloughs. The other refuges from which most of the raccoons ranged so widely are hilly and, with few exceptions, are watered by relatively small streams. Some are partly in cultivation. This diversity of environmental conditions between the original habitat of the raccoons and the terrain into which they were introduced may well have been the cause of their unrest and haphazard scattering.—LEROY W. GILES, *Arkansas Game and Fish Commission, Fayetteville, Ark.*

SMALL ENTRANCE TO A WOOD DUCK NEST

As a part of field investigations concerned with raccoon management at the Swan Creek Wildlife Experiment Station, Allegan County, Michigan, many hollow trees were examined. The Kalamazoo River flood plain at the station is one of the better wood duck nesting areas in the state, and several nesting sites of this duck were found in the search for 'coon dens.

One such hollow occupied by a brooding female wood duck had a surprisingly small entrance. If wood ducks can use such small holes regularly, this fact should be of value to persons erecting artificial nest boxes, especially where raccoons are present in sufficient numbers to disturb nesting ducks seriously. There was some evidence that 'coons broke up a few wood duck nests in boxes. In California, Dixon (Condor, vol. 26, pp. 41–46, 1924) regarded raccoons as serious predators of this duck. Workers in Illinois also have noted similar predation.

A full grown raccoon has difficulty in entering a hole as small as 4″×4″, although some entrances of that size were found in this study to have been entered by 'coons of unknown age. The small entrance used by the wood duck at Swan Creek measured only 4″×2½″. Even a yearling raccoon could not enter a box with so small a hole, and juvenile raccoons of the year are not out in search of food until the wood duck nesting season is over. The possibility of 'coons preying upon birds in artificial boxes could be eliminated by use of small entrance holes about two feet above the nest box floor. The animals could then neither enter nor reach the nest with their front feet.

The hollow containing the duck nest measured 11″×11″ in diameter, with the floor only 7″ from the entrance, which faced the north. The opening was 37½ feet from the ground in the trunk of a red maple, situated about 300 yards from the Kalamazoo River. The female duck was brooding eight eggs in the nest on April 30, 1940.—FREDERICK W. STUEWER, *Game Division, Department of Conservation, Lansing, Michigan.*

NEWS NOTES

The annual meeting of The Wildlife Society at Denver on February 15, 1943, voted to suspend publication of *The Wildlife News* during wartime and to issue the annual list of members in mimeographed form, both changes being made to provide more funds for printing original articles in the *Journal*. Members are asked to send news items of general interest to the Editor of the *Journal*. The annual reports of officers will appear in the July issue.—Tracy I. Storer.

EIGHTH NORTH AMERICAN WILDLIFE CONFERENCE

The Conference and a series of meetings by related organizations and groups were held in the Cosmopolitan Hotel, Denver, Colorado, February 15 to 17, 1943. Nearly 300 persons were in attendance. Many papers and discussions emphasized the effects of wartime conditions on wildlife affairs.

GENERAL SESSIONS

CONTINENTAL DAY. Addresses by F. C. Walcott (*Chairman*), the Mayor of Denver, the Governor of Colorado, Hoyes Lloyd representing the Dominion of Canada, Juan Zinser representing the Republic of Mexico, and O. C. Chapman, representing the U. S. Department of the Interior.

WARTIME UTILIZATION OF WILDLIFE CROPS. *Chairman:* Seth Gordon, Pa. Game Comm.

Keeping up the game harvest. E. F. Warner, "Field and Stream."

Potentialities of wildlife harvest. I. T. Bode, Mo. Conserv. Comm.

Utilization of aquatic resources. Kenneth A. Reid, Izaak Walton League.

Utilization of marsh resources. A. M. Bartley, Ducks Unlimited.

Wartime uses of wildlife products. A. M. Day, Fish & Wildlife Ser.

LOOKING AHEAD IN CONSERVATION. *Chairman:* David A. Aylward, Natl. Wildlife Fed.

Migratory fishes. W. J. Finley, Natl. Wildlife Fed.

Pollution. Karl E. Mundt, U. S. Congress.

Wildlife and livestock on western ranges. A. L. Linger, Colo. Woolgrowers' Assn.

Wild lands. A. S. Peck, Forest Service.

Procurement of ammunition for other than military purposes. L. W. Lipscomb, War Production Board.

Summary and recommendations from the technical sessions. T. I. Storer, Univ. Calif.

TECHNICAL SESSIONS

METHODS OF HANDLING BIG GAME CROPS DURING WARTIME. *Chairman:* Lester Bagley.

Wildlife management in wartime. Ross Leonard, Utah Fish & Game Comm.

Elk management and herd regulation, Yellowstone National Park. V. H. Cahalane, Fish & Wildlife Serv.

Regulated wildlife management areas on the national forests in the south and southeast. E. A. Schilling, Forest Serv.

Reindeer: an Indian Service contribution to the war. C. C. Presnall, Fish & Wildlife Serv.

Wyoming antelope—history and wartime management. W. J. Allred, Wyo. Game & Fish Comm.

Management for maximum production. E. S. Barker, N. Mex. Fish & Game Comm.

POND AND SMALL LAKE MANAGEMENT. *Chairman:* M. C. James, Fish & Wildlife Serv.

Weed control in hard-water ponds with copper sulphate and sodium arsenite. E. W. Surber, Fish & Wildlife Serv.

Effect of management practices from 1932 to 1942 on the catch in a 12.5 acre pond. H. S. Swingle and E. V. Smith, Ala. Polytechnic Inst.

Construction features control emergent water plants and improve fishing. V. E. Davison, Soil Cons. Serv.

Natural production of pondfish in waters near Tulsa, Oklahoma. A. D. Aldrich, Tulsa Municipal Fisheries.

Results of further experiments on the stocking of fish ponds. E. V. Smith and H. S. Swingle, Ala. Polytechnic Inst.

Preliminary report on the fisheries of Lake Meade. J. W. Moffett, Fish & Wildlife Serv.

EDUCATIONAL FORUM. *Chairman:* G. O. Hendrickson.

Field trips in wildlife management. L. W. Wing, Wash. State College.

A wildlife conservation teaching program. W. B. Davis, Texas A. & M. College.

Wildlife—an essential resource. P. F. English, Pa. State College.

An outdoor living and physical training course. S. A. Graham, Univ. of Michigan.

METHODS OF HANDLING SMALL GAME CROPS DURING WARTIME. *Chairman:* Rudolf Bennitt.

Pheasant weights and time of season in relation to meat production in Nebraska. L. L. Mohler, Nebr. Game Comm.

Louisiana muskrat industry as a source of human food. J. N. Gowanloch, La. Cons. Dept.

Regional papers:

Northeast. John Pearce, Fish & Wildlife Serv.

Southeast. V. E. Davison, Soil. Cons. Serv.

Midwest. W. W. Chase, Soil. Cons. Serv.

Great Plains. O. J. Murie, Fish & Wildlife Serv.

Southwest. Phil Goodrum, Texas Game, Fish & Oyster Comm.

West Coast. Arthur Einarsen, Fish & Wildlife Serv.

ECONOMIC UTILIZATION OF ROUGH FISH. *Chairman:* Edward Schneberger.

Michigan's program to encourage wider utilization of the less popular varieties of fish. F. A. Westerman, Mich. Dept. of Cons.
P. I. Tack, Mich. State College.
A. S. Hazzard, Inst. for Fisheries Research.

The war as an opportunity to develop a more balanced program of freshwater fishery management through increased use of coarse fish as food. J. V. Skiff, N. Y. Cons. Dept.

Carp control and utilization during the war. R. A. Gray, Wis. Cons. Dept.

Neglected species of fish. Ralph Russel and F. H. Meisnest, Fish & Wildlife Serv.

Problems of removal and utilization of rough fish in Iowa. E. B. Speaker, Iowa. Cons. Dept.

Feeding fish to fur animals. C. E. Kellogg, Fish & Wildlife Serv.

FUR RESOURCES FORUM. *Chairman:* F. G. Ashbrook.

Fur production and management of Illinois drainage ditches. L. E. Yeager, Ill. Nat. Hist. Surv.

Wartime status of beaver in the Western United States. A. B. Hatch, Fish & Wildlife Serv.

Some aspects of administration of wild fur resources in the south. D. W. Lay, Texas Game, Fish & Oyster Comm.

Experimental beaver transplanting in Utah. D. I. Rasmussen, Utah State College.

Effect of the war on fur farming. G. E. Broyles, "The National Fur News."

Round table discussion of conditions affecting fur production and fur trade development.

MISTAKES MADE IN WILDLIFE MANAGEMENT. *Chairman:* C. N. Feast.

Wildlife management—fact and fancy. Gardiner Bump, N. Y. Cons. Dept.

Direct relationship of predator control on big game areas. A. C. Randall, Utah Fish & Game Comm.

Fallacies in winter feeding of deer. A. H. Carhart, Colo. Game & Fish Comm.

Problems resulting from creation of refuges for big game. B. C. Park, Forest Serv.

Ill-advised legislation as affecting game management. J. D. Pender, Denver.

Over-stocking trout streams. T. K. Chamberlain, Fish & Wildlife Serv.

RECENT DEVELOPMENTS IN WILDLIFE TECHNIQUES. *Chairman:* T. I. Storer.

Land classification as a technique in wildlife management. E. H. Graham, Soil Cons. Serv.

Census methods and their application in study of mule deer. D. I. Rasmussen, Utah State College.

Recent developments in upland game census technique. P. D. Dalke, Mo. Coop. Wildlife Research Unit.

Some unregarded factors in creel census studies. Stillman Wright, Fish & Wildlife Serv.

Hunter distribution—studies and methods. F. W. Johnson, Forest Serv.

Birds, rodents and colored lethal baits. E. R. Kalmbach, Fish & Wildlife Serv.

Principles and problems of rodent control. E. E. Horn, Fish & Wildlife Serv.

REVIEW

Voles, Mice and Lemmings: problems in population dynamics. Charles Elton. 6+496 pp., frontisp. 22 figs., 64 tables. Oxford, Clarendon Press. $10.00.

In its treatment of the fluctuations of animal populations, the factors causing them, and the means for their control, Elton's volume ranks with Leopold's "Game Management" as a great book. No one is better qualified to discuss this subject. Elton is a pioneer in the study of animal populations, and probably has had more influence on its development than any other living ecologist. In the Bureau of Animal Population at Oxford, he has built a unique and well-equipped organization to investigate population dynamics. His latest book is one result of sixteen years' research in this corner stone of wildlife management and should be read by everyone interested in the principles and practice of conservation.

The author hopes "that the numerous lines of evidence brought together in this book will leave in the reader's mind the realization that there is a general phenomenon of world-wide extent for which quite new methods of research are being developed." This is the natural oscillation of animal numbers, clearly illustrated in plagues or outbreaks among small, mouse-like rodents. These "key" animals are important agents in the transformation of plant to animal, a liability to the herbivorous competitor and an asset to the predatory carnivore. Their fluctuations have far-reaching effects upon wildlife from the Arctic to Australia. The dynamic nature of animal populations was realized intuitively by Herbert Spencer and later verified on a mathematical basis by Lotka and Volterra; Elton gives this concept life and reality by vivid description of the events occurring in nature. In the book, Part I is "a panorama of vole and mouse plagues" in France, Germany, Holland, Italy, the Balkans, Russia, Palestine, Australia, the United States, and Canada. The general facts of ancient record and present incidence provide the necessary background. Part II con-

siders "the vole and mouse fluctuations that occur in Great Britain and Scandinavia, and the methods developed at Oxford for the study of population dynamics in the field and laboratory." Some of these modern research techniques are applied in Parts III and IV to the wildlife cycles of Northern Labrador and Ungava, and reveal the dominant role of rodents in the Canadian fur-trade.

A typical rodent outbreak occurred in the lowland hills of Scotland in 1890–92. Much of the area then was covered with grassy moors and grazed by sheep. Complaints of damage by voles (*Microtus agrestis*) came from a few farmers in 1890, but the seriousness of the situation was not fully appreciated until the spring of 1892, when so many pastures had been destroyed that the sheep had to be fed from outside sources, many lambs died, and there was little prospect of a crop of hay in the following summer. By the end of 1892 an estimated 100,000 acres or more had been badly infested. One farmer reported killing 15,000 voles in a month. Predaceous birds appeared in abnormally large numbers. The Scottish Board of Agriculture took belated action only when decrease in the voles was evident. In the spring of 1893 many were dead or dying, birds of prey perished or disappeared, pastures recovered rapidly, and a great lamb crop ensued.

Similar plagues occur in many parts of the world and in many species. In England and Scotland, with but few species of rodents, the British vole predominates in outbreaks; in the rich fauna of Soviet Russia, over a dozen species cause great crop damage by mass increases; in Australia the alien house mouse assumes the chief role; in Germany, Scandinavia, the United States, and Canada outbreaks have been known to recur in given areas at intervals of three or four years. The general occurrence of plagues under widely divergent conditions and the similar periodicity of European and North American cycles point to the operation of master factors other than chance.

"One does not need to be particularly cynical to gain some measure of amusement and wonder from the ecological spectacle that fur-trade inter-relationships in the north afford. Of the many links some can be seen quite clearly: mouse, red fox, Indian, fur-trader, shareholder, costumier, customer, pawnbroker . . . " From the archives of Moravian Missions and the Hudson's Bay Company, Elton has drawn a graphic picture of the Arctic struggle for existence. At scattered posts a few white men exchange with small bands of Indians and Eskimos the benefits and drawbacks of civilization in return for the prized skins of marten, mink, fox and other fur-bearers. The natives lead a precarious life, suffering a slow cycle much like that in the animals. For food and clothing they depend in part upon the caribou; its fluctuations are undoubtedly influenced by predation, human and other. Eskimo sledge-dogs periodically develop epidemic diseases strikingly similar to those of foxes. All of these factors may affect the number of furs brought in, but the fur-returns show a remarkable periodicity of about four years, even to the casual observer. Elton goes to considerable length to eliminate all possible errors of interpretation, and to show that this fur cycle rests in fact upon a four-year cycle in voles and lemmings. Correlation of these two cycles indicated that peaks in fur-bearers follow by a year the peaks in rodents. This lag is reflected also in periodic migrations of the snowy owl, rough-legged hawk, and northern shrike. "The situation is rather like a gold-rush for which men will drop their trades and carefully learned habits and turn to the sudden new resource that holds out such enormously high promises of luxury and wealth. The aftermath is not unlike, too."

Throughout the book there is a constant search for causes of the rodent outbreaks. The mathematical theorists propose an inherent rhythm of increase and decrease independent of environmental features; factors in the external environment usually come under four headings: disease, predation, supply of food and cover, and climate. Elton makes it clear that none of these yet has solved the problem, but none can be disregarded entirely. Little is known of innate rhythms; disease does not seem always to be present in population crashes; predation apparently is of secondary importance. Nutritional disturbances and their effects are now deservedly attracting attention. The direct and indirect effects of climate are known to be much more complex than was formerly imagined. Elton long ago abandoned his tentative hypothesis of a sun-spot correlation, but weather cycles may yet offer a valuable clue. The book does not offer a general solu-

tion to the problem of outbreaks and frankly admits the extent of our ignorance.

The ancient resource to prayers and holy water and the more modern use of traps and poison have two features in common—they always work and they never prevent the next outbreak! Temporary suppression is clearly not enough; control is needed. Chapter III summarizes the use of bacterial or "virus" cultures in France and is the best discussion to date of this form of biological control. Despite risks of infection for man and other animals, the French are convinced of its success by many field trials. As Elton says, however, these artificial epidemics may simply accompany reduction of numbers by natural causes. Bacterial control indeed may be attended by an apparent increase in the power of recovery of the voles. Clearly we are not yet in position to use such means with confidence and further research is desirable. Reduction in the carrying capacity of vole cover on cultivated lands by improved agricultural methods may offer a more promising type of control measure.

"During the course of the last hundred years the control, or attempted control, of field-mice has fallen gradually out of the hands of the local god into those of the local government." Modern methods remain essentially primitive. The course of a typical large-scale outbreak is described thus: "We have the crop destruction, and belated efforts at control of the mice; the natural end to the outbreak; . . . the sigh of relief among politicians when the crisis has passed before any permanent organized study of the problem need be set up; and the recrudescence of the trouble in much the same form a few years afterwards." Elton pleads strongly for increased organization as the most effective attack on the problem. He illustrates this (Chap. V) by an excellent discussion of the Soviet contributions, derived under a unified national rodent research program. Elton early realized the need of organized investigation, and his subsequent efforts led to creation in 1932 of the Bureau of Animal Population, one of the most truly cooperative scientific enterprises. It might well be considered the prototype of the utopian "Central Field-Mouse Staff Office of a World State(CENMOSO for short)" which the author visualizes in Chapter I. In the present Bureau one member is a pathologist, one a statistician; a third maintains a laboratory stock of voles; some are engaged in field work; others do their research in libraries or archives. Each concentrates on a particular problem, but almost every project requires and receives the cooperation of all. The ingenious methods and techniques devised to study populations are summarized in Chapters VIII and IX, and include: a system of questionnaires to elicit more accurate knowledge of wildlife cycles; a study of the mortality, fertility and rate of increase of voles in the laboratory and field; and census and marking methods to follow the fluctuations and movements of animals. The promising results fully justify the contention that in union there is strength.

Nowhere else has the rodent story been told so thoroughly and so well. "Voles, Mice and Lemmings" is scholarly but not scholastic, carefully avoiding the terminology of ecological pedants. Rich in wit and humor, it is a brilliant exposition of the Eltonian method and an excellent demonstration of science expressed in simple language. There are remarkably few typographical errors. The assignment of Mt. Rainer to New York State marks the author as a man who can move mountains! The publication of exhaustive (and exhausting) records in the text rather than in an appendix is justified in the enlightening words of Uncle Remus: "I ain't 'sputing about it, but I ain't seed um, an' I don't take no chances deze days on w'at I don't see, and dat w'at I sees I got to 'zamine mighty close."

American zoologists may be disappointed to find that the account of rodent work in the United States, where live "about half the species of voles in the whole world," is confined to fourteen pages. Africa and South America have been referred to only in passing. The world picture is not yet complete, and opportunities for further research are great. "It is to be hoped that the reader of this book will by now have seen that we stand on the near shore of an ocean larger than any that Columbus explored, in which we can at present discern only a few islands rising out of the mist. Let us hope that wise governments will train investigators and equip them to explore more closely the Islands of Vole, Mouse and Lemming; and that they will do so not only in order to round Cape Fox and cross Dog Deep, but with some idea of understanding, not for power alone, but on account of its own wildness and interest and beauty, the unstable fabric of the living cosmos."—F. C. EVANS, *University of California, Davis, Calif.*